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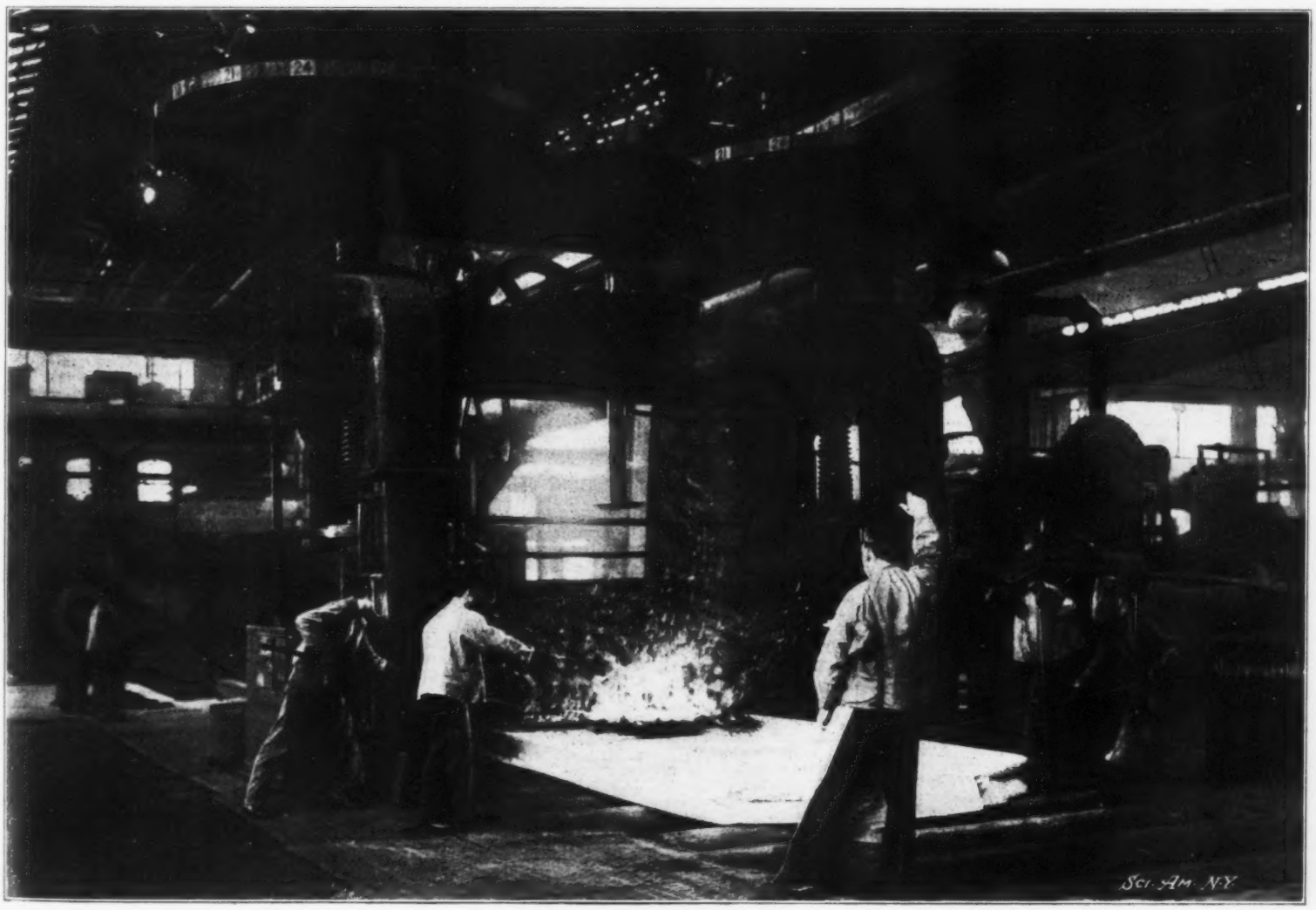
CASTING IN THE GREAT FOUNDRY.



ROLLING A HEAVY ARMOR PLATE.

THE KRUPP WORKS AT ESSEN.—II.

[Concluded from SUPPLEMENT No. 1427, page 22862.]

THE KRUPP WORKS AT ESSEN.—II.*

By DAY ALLEN WILLEY.

BOTH Friedrich and his son, Alfred Krupp, believed that a successful industry should own not only the facilities for production, but the sources of raw material forming the base, and this is why the coal and ore mines in connection with the blast furnaces form such a notable adjunct of the enterprises under consideration. One of the principal coal mines is located practically on the site of the Essen works, the other two being situated near Bochum. In all they comprise seven working pits, of which three are at Essen. The former have a maximum depth of 1,700 feet, and at present no less than ten veins of coal are being worked on two levels, the veins varying from 2½ to 6 feet in thickness. Most of the coal is secured by hand mining, but the works are equipped with both overground and underground draining machinery, a hydraulic air compressor for operating ventilators, while a separating and washing floor is installed, which has a capacity of 100 tons hourly. The workings near Bochum contain thirty veins with a total thickness of 112 feet. They are much more extensive than the pits at Essen, and furnish most of the total output of the Krupp mines, which represent nearly 1,500,000 tons yearly. They are also provided with overground and underground draining machinery, as well as hydraulic air compressors, which have a capacity of 10,000 cubic feet hourly, in addition to four ventilators and four separation plants, treating 200 tons an hour. In connection with the mines are sets of coke ovens having a total daily output of 700 tons. These are of the vertical type served from above, but are not provided with apparatus for securing by-products, such as is installed in most of the modern ovens of the United States. The various groups of iron-ore deposits produce annually about 520,000 tons. They include, as stated, 667 different allotments, producing hematite and red ore as well as manganese. The Krupp interest in the Spanish mines is held under the title of the Orconera Iron Ore Company, and a line of steamships owned by the Krupps is devoted to its transportation to Germany.

The blast furnace capacity is not as large as might be imagined when contrasted with the capacity of the other works. The principal plant, the Rheinhausen, is comparatively new, being built in 1896. It includes three furnaces of 14,150 cubic feet capacity each, producing from 200 to 225 tons every 24 hours. The furnaces are provided with steam hoists, four Cowper heaters, and produce principally Bessemer and hematite pig iron. An interesting feature in connection with the plant is the service of the ore, a series of Brown hoist conveyors electrically driven being used for transferring the ore from shipboard to the plant. The blowing engines are of the vertical compound type, furnishing 32,000 cubic feet of air per minute, but the power plant also includes a gas engine fed by furnace gas which operates an electric motor, two 250 horse power steam engines for operating dynamos, and two compound pumping engines. The other furnaces produce the balance of the 1,900 tons daily, which is the average output of this division of the Krupp industries. They include four furnaces at Mülhofen works, three at Hermanns works, and four at Johannes works, but none are of modern type.

The Germania shipyard, or the Kiel plant as it is sometimes called, after the name of the city near which it is located, is one of the oldest in Europe. Originally a specialty was made of marine engines and boilers. The present works were located at Gaarden, a suburb of Kiel, in 1865, and were leased by the Krupps in 1896, and only purchased last year. Friedrich Krupp realized their value as an adjunct to his other industries, and since they have been under the present control, they have produced marine architecture, not only in battleships, cruisers, and smaller war vessels, but merchant vessels. While the plant at present in use has a frontage on Kiel Harbor of about 1,300 feet and covers 350 acres of ground, an additional area has been purchased, which is more than double its present capacity. As it is, slips are provided for the construction of seven vessels at one time, the slips ranging in length from 377 to 640 feet, with a width of from 85 to 100 feet. Three others which are planned will range from 600 to 836 feet each, but as will be noted from the dimensions, the facilities are such that the largest type of battleship yet planned can be built in the most capacious of these inclosures. They represent the latest idea in construction, the lower portion being of concrete with side walls of granite, and are closed by pontoons. Four are inclosed with glass roofs and sides, but are sufficiently lofty to allow the use of overhead traveling cranes operated by electric motors, so that the material can be transferred in this manner without delay. One of the most extensive is so arranged that a flotilla of four or five torpedo boats of the ordinary size can be constructed at once if desired.

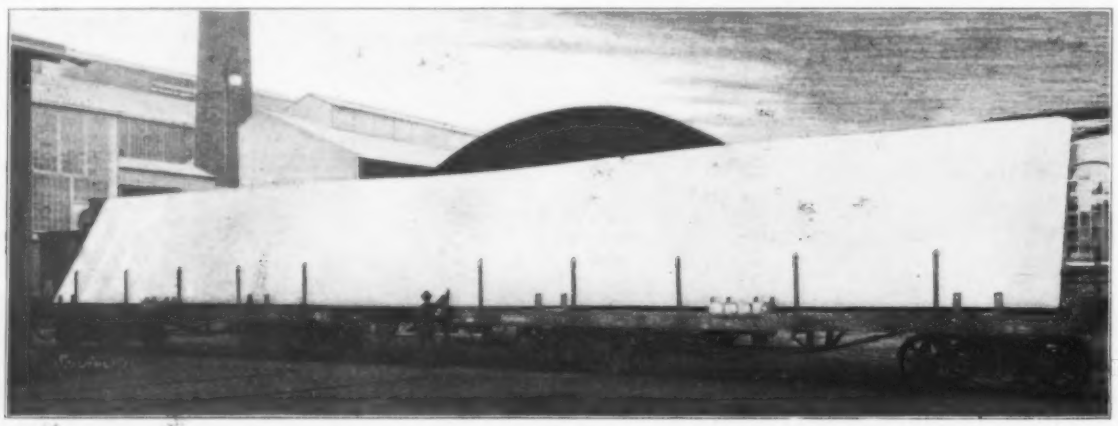
The mechanical equipment is on a par with the Essen works in design and capacity. The various departments, such as the forging, fitting, and bending shops, the plate yards, mold loft, joiner and paint shops, are provided with a complete outfit of steam and electrically-driven machinery. Other notable divisions are a plant for model making, also for the manufacture of cylindrical and water-tube boilers, a copper-forging plant, and a plant for testing marine boilers and engines. The equipment includes about 1,000 machine tools in addition to 10 steam hammers and 72 hydraulic and electric cranes. The electric power is distributed by a series of 260 dynamos and motors. It is at the Germania yard that the celebrated 150-ton crane has been installed for placing ordnance, engines, and other heavy weights on battleships and merchantmen.

Reference has already been made to the importance of this plant in the construction of war vessels. Among the notable craft completed are four battleships for the German navy, including the "Wörth," of 10,000 tons, the "Zähringen," of 11,800 tons, and another ship recently placed in commission of 13,000 tons. A number of the principal naval vessels, such as the battleship "Baden," have been rebuilt. Recent additions to the fleet of German cruisers, such as the "Prinzess Wilhelm," "Nymphe," and "Amazone," were constructed in these slips. One of the most notable pieces of work was the "Askold," for which the company secured the contract from the Russian government in competition with several other German firms as well as Italian and Russian yards. This cruiser, which is of 6,000 tons, was not only built for speed, but to carry unusually powerful batteries. She presents a peculiar appearance from the fact that she carries five funnels. After being completed she attained a speed of no less than 24 knots an hour with her triple screws, one knot more than the required rate, developing 19,999 horse power. Among the additions to Germany's merchantmen built at the Germania yard are the Lloyd ships "Bonn" and "Halle," also the famous "Kaiser Wilhelm der Grosse," which has made such a record in trans-Atlantic service.

The enlargement of this yard, carried out as planned by the late Friedrich Alfred Krupp, will make it probably the greatest shipbuilding plant in the world, and give it facilities for turning out more than twice the tonnage which its former capacity represented, as a considerable portion of the present works will be rebuilt. It will cover an area of 600 acres, and employ about 3,000 more men than the old yard, when all of the new shops are in operation. Most of the improvements have been completed.

Two interesting features in connection with the industries described are the proving grounds for ordnance at Meppen, laid out in connection with the Essen works, also the Gruson works. It is here that the tests have been made which have given the Krupp guns such a reputation among military experts, owing to the elaborate and costly trials, which have not only included ordnance, but projectiles and armor plate. Sections of every kind of armor plate manufactured to fill orders are carried to these grounds and attacked by ordnance of varied caliber. Every piece of artillery is also tested at one of the proving grounds before being sent away from the works.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.



SINGLE SHEET OF METAL ROLLED AT THE ESSEN WORKS.

THE DECAY OF METALS.*

By J. T. MILTON, M. INST. C. E., and W. J. LARKE.

THE durability of metals under the conditions in which they were actually used is of great importance, and must always receive as careful consideration from engineers as questions of strength or cheapness. Copper, brass, gun-metal, and other alloys were chosen for use on account of their durability; but even these metals were sometimes found to corrode or decay under seemingly obscure conditions. It was to cases of such decay, and to a discussion on their probable causes that this paper is devoted.

The following examples of the decay referred to are adduced:

1. The pitting of the tubes of marine surface-condensers.

2. The decay of brass or yellow-metal bolts in composite vessels, and in the under-water fittings of iron and steel ships.

3. The decay of the brazing-metal in copper steam-pipes.

4. The deterioration, as distinguished from oxidation, of cast iron used for parts of marine engines, and also for other appliances which were in frequent or continuous contact with sea-water.

5. The decay of some propellers made of the patent bronzes when fitted to copper-bottomed vessels.

In the case of condenser-tubes it was apparent that some of the metal became eaten away into holes, while in the other cases mentioned the metal appeared to retain its original form. The former action is "corrosion," and the latter "decay."

Chemical analysis of the decayed portions showed that a change had occurred in the composition of the metal, but did not explain why its strength and properties were so completely modified. It showed that in copper-zinc alloys the process had been mainly one of dezinckification, or loss of zinc, while in cast iron, part of the iron, and possibly also of the manganese, had disappeared, the whole of the graphitic carbon remaining.

Although the decay of copper-zinc alloys had been known for many years, the first published research into its cause appears to have been made by Prof. Arnold, who in 1898, investigated the case of the failure of a marine boiler steam-pipe. He pointed out that the brazing-metal of the pipe, when microscopically examined, was seen to possess a duplex structure, similar to that of Muntz metal, both constituents being definite chemical compounds of copper and zinc, but one richer in copper than the other; and he attributed the decay to local galvanic action set up between these constituents, whereby in the first stage, the one less rich in copper becomes dezinckified, and subsequently that richer in copper also lost its zinc, the whole then becoming a spongy mass of copper.

Microscopic study showed that the Muntz metal tube-plates, rods, etc., had been subject to similar decay to that pointed out by Prof. Arnold, and also that in the decay of cast iron the complexity of structure doubtless led to the same result, the decay in this case advancing along the lines of the graphite plates and leaving the phosphide eutectic portions till the last.

This explanation of local galvanic action, however, did not account for the corrosion and decay of condenser-tubes which were made of an alloy not having a duplex structure; nor did it explain why cast iron in some cases did not decay, even although its composition and structure were the same as in other cases where decay took place.

Condenser-tubes were usually made of an alloy consisting of, nominally, 70 per cent copper and 30 per cent zinc. The Admiralty specification was, not less than 70 per cent copper and 1 per cent tin, the remainder being of zinc; while one of the large mail steamship companies, as the result of considerable experience, had the tubes made of 78 per cent copper, 21 per cent zinc, and 1 per cent tin.

These were nominal compositions, for commercial copper and zinc were rarely pure. If the impurities became uniformly diffused through the mass of the alloy it would still be homogeneous, but if they had a tendency to segregate, as it was well known some elements did in steel, there would still be such want of uniformity as might set up local galvanic action and lead to local pitting or corrosion. Segregation was not only possible during the solidification of the alloy in the original casting, but might also occur while the metal was at a high temperature during the operation of annealing, which was several times repeated in the course of the drawing process.

If segregation occurred during solidification only, the drawing process would cause the impure portions to be much elongated in the direction of the tube's length, and the resulting corrosion would be seamy; whereas if it occurred also to a marked degree during annealing, the corrosion would affect more rounded areas. Examination of the insides of condenser-tubes revealed cases of deep corrosion of both kinds; but in addition it was seen that the general surface of the inside of the tubes had become partially dezinckified to an extent sufficient to cause it to crack when the tube is flattened.

In order to determine whether the various impurities which are commonly present in copper-zinc alloys do tend to segregate or diffuse during annealing some experiments, detailed in an appendix, were made. These experiments incidentally threw some light upon the changes of structure which Muntz metal, and also the 70 to 30 copper-zinc alloy underwent, due to changes of heat treatment.

Considerable protection is given to copper-zinc alloys,

* Abstract of a paper presented before Institution of Civil Engineers.

when exposed to the action of sea water, by the practice, adopted by the Admiralty, of requiring the addition of at least 1 per cent of tin to all such alloys.

The conclusions arrived at were:

1. Iron.—Beyond the very small portion which doubtless existed in a state of solid solution in the brass, iron occurred in combination with zinc as small isolated particles, which were neither diffusible nor liable to segregation. These particles were probably a zinc-iron alloy.

2. Lead.—A small portion of this metal would also exist in brass in a state of solid solution; but beyond the saturation point, lead did not diffuse into brass. A small proportion, however, in solid solution, materially increased the liability to corrosion.

3. Tin.—This metal could exist in small proportions in solid solution in brass and in Muntz metal. In the latter it probably entered into both micro-constituents; but when present it certainly occurred in the one which was richest in zinc, as was shown by the protective effect it gave to this constituent against corrosion in sea-water. In larger quantities, tin would also diffuse into brass, the extent of the diffusion depending upon the temperature to which it was raised.

4. Zinc.—Zinc alloyed with copper in all proportions, and if it was not uniformly distributed through the metal, it tended to become so by prolonged heating.

Some experiments were also made to determine the galvanic action between copper, iron, brass, Muntz metal, etc., when in contact with sea-water; and other experiments showed that weak applied currents, when long continued, had a decided corrosive action upon copper and its alloys when immersed in sea-water, the amount of corrosion—with the same current—being greatest in those containing the highest proportion of copper.

With a current of 0.001 ampere acting on an immersed area of 40 square centimeters in the case of Muntz metal, the wasting produced was confined to the dezinckification of the constituent poorest in copper; but the same current, acting upon 60 square centimeters of ordinary brass condenser-tubes, gave rise to a fairly uniform corrosion, both the copper and the zinc of the alloy being dissolved.

Summarizing the results of the investigation it would appear that—

1. Decay was more frequent in metals which had a duplex or more complex structure than in those which were comparatively homogeneous.

2. Decay was due to a slower or less energetic action than that causing corrosion, and, moreover, it required an action which removed part only of the constituents of the metal, whereas corrosion removed all the material attacked.

3. Both decay and corrosion might result from chemical action alone, or from chemical and electrolytic action combined.

4. Pitting, or intense local corrosion, was probably often due to local segregation of impurities of the metal, but it might also in some cases be due to local irregularities of surface or structure producing local irregularities in the distribution of galvanic currents.

5. In the case of brass exposed to sea-water, tin was distinctly preservative, while lead and iron were both injurious, rendering the brass more readily corrodible. The percentage of the latter elements should, therefore, be kept as low as possible in the case of all metal intended for purposes where contact with sea-water was inevitable.

6. With a view to obtain a minimum of corrosion, the internal surfaces of condenser-tubes should be as smooth and uniform as possible; and in order to insure this, the cast pipe from which they were drawn should be smoothly bored inside, either before the drawing was commenced, or in an early stage of the process, as was done in the manufacture of brass boiler-tubes.

7. The experiments with an applied current show that electrolytic action alone, even where exceedingly minute currents were in question, might result in very severe corrosion or decay. Every effort, therefore, should be made to prevent such action, by careful insulation of all electric cables. Where galvanic action was inevitable through the proximity of different metals exposed to the same electrolyte, the currents resulting should be neutralized by the application of zinc plates in the circuit, so arranged that they would be negative to both of the other metals.

ON THE "EMANATION SUBSTANCE" FROM PITCHBLENDE, AND ON RADIUM.*

By F. GIESEL.

THE radio-activity of the compounds of thorium and their characteristic emanation has been very thoroughly investigated by Rutherford (cf. E. Rutherford and Soddy, Zeit. für Physikal. Chem., 1902, xlii., 81). His endeavors to prove that the relatively very insignificant activity of thorium is due to the presence in very small quantity of a strongly active substance were unsuccessful. It is true that Rutherford, by extraction of thorium hydroxide with water, or by precipitation of thorium salts with ammonia, obtained, after evaporation or expulsion of the ammonia respectively, small residues almost free from thorium, which were considerably more active than the thorium used, but the properties of these residues were altered. While the thorium by such treatment had lost a part of its activity, after some time it regained its original activity, but, on the contrary, the extracted substance, which Rutherford called "ThX," gradually decreased in activity up to the amount of the thorium present.†

Hence Rutherford concluded that the thorium itself must be the primarily active substance, and that "ThX" is formed from it continually by rearrangement of the atoms.

Now, I have obtained a body from pitchblende (Berichte, 1902, xxxv., 3610), which, first, possesses to a considerably higher degree the same kind of activity as thorium, and secondly, unlike "ThX," has not diminished at all in linear radiation and emanation in about six months. But as the physical properties agree in other respects, and as it also appears to be related to thorium (and the rare earths), from these two new facts mentioned above we are led to adopt a different view from Rutherford's concerning the origin of the activity of thorium.

The emanation substance of pitchblende belongs to the group of cerium earths, or at any rate reacts in the same way. I have already shown (Berichte, 1902, xxxv., 3611) that the rare earths obtainable from pitchblende possess a constant activity. I was not then able to observe an emanation* because this, as has already been shown, does not belong equally to all compounds, but is dependent upon chemical conditions.

The method of preparation of the raw material for the emanation substance is the same as that employed for the separation of the rare earths, and is best effected by means of potassium sulphate, after removal of the heavy metals. Hydrogen peroxide gives with the solution of the potassium double salt a fairly active precipitate, displaying the emanation. The precipitate with oxalic acid, which also contains the emanation substance, and in consequence of the large amount of didymium contained in it is colored faintly pink, yields no emanation. But a thoroughly rested eye may also perceive the activity of this last precipitate on the luminous screen.†

The preparation of this material, which is to be obtained in great quantity, must be deferred to a future period. For the present research the mother-liquor freed from radium bromide, sufficed; this has already been rendered richer in the emanation substance, i. e., it contains it least adulterated with inactive earths. The treatment of this consisted in dissolving in hydrochloric acid the precipitate obtained with ammonia, after removal of any barium precipitated with it by means of sulphuric acid, and evaporating to dryness on the water-bath. On taking up the residue after evaporation with water, several centigrammes of an insoluble residue remained behind, which yielded the most strongly active (emanation) substance yet obtained. This residue was not investigated but reserved for the physical experiments.

The filtrate gave with sulphureted hydrogen only a small active precipitate which contained lead. The precipitate obtained afterward with oxalic acid amounted to about 2 grammes after further purification, and was almost as inactive as the insoluble residue. The precipitate formed by adding ammonia to the filtrate, and the final precipitate consisting of magnesia formed on addition of ammonium carbonate, were less active. Also the small remaining residue left on driving off the fumes from the last filtrate after evaporation was very active.

All precipitates, with the exception of those formed by oxalic acid and sulphureted hydrogen, showed emanation which generally increased in the first few days. The ammonia precipitate, as well as the magnesia precipitate, contained small impurities of rare earths, after separation of which the activity correspondingly diminished, and grew stronger in the latter.

The oxalate of these earths becomes almost white on ignition, with a very faint salmon tint, and is then easily soluble in hydrochloric acid. The solution is at first orange, and becomes colorless with evolution of chlorine; similarly the solution in nitric acid on addition of hydrogen peroxide, but only very little cerium is obtained as hydroxide by the hydrogen peroxide reaction. The concentrated solutions of the salts show no trace of an absorption spectrum, and thus are practically free from didymium. Potassium sulphate, as well as hydrogen peroxide, completely precipitates the solution of the potassium double salt, which last gives also an emanation. Thiosulphate gives no precipitate on boiling, only a very slight turbidity. Ammonium oxalate does not extract from the oxalate sufficient thorium to be precipitated by ammonia. After driving off the ammonium salt a trace remains, which, however, is not more active than the undissolved oxalate. But it is noteworthy that the oxalate thus treated then gives the emanation very strongly.

Like the lanthanum salt the chloride crystallizes easily, is itself phosphorescent after removal of water, and shows the emanation. In the Bunsen flame only the sodium line is visible spectroscopically. The sulphate forms definite crystals, and has no emanation or phosphorescence. According to these reactions thorium cannot be present to any material extent, and the traces present cannot be the cause of the activity. Lanthanum appears to be the essential impurity. It may be mentioned that the percentage amount of this earth present in a new radio-active element must be about 0.1 per cent, if it be assumed that the Becquerel radiation possesses the same intensity and the same power of penetration as in the case of radium. The Becquerel radiation of the preparation thus affects the barium platinum cyanide screen in the same degree as a barium carbonate with about 0.1 per cent radium. For a smaller intensity and power of penetration of the linear radiation than in the case of radium the percentage content would of course be higher. Thus in the case in question about 2 grammes must contain at least 2 milligrammes of the element. From what has already been stated, this can be neither radium nor polonium. For the present I will not follow the custom, usually adopted from practical considerations, of giving a name to the hypothetical element, until it has been established how Debierne's substance (actinium), hitherto known only as thorium, also behaves as regards the emanation.

In the examination of the physical properties of the emanation substance the following results have been obtained:

The linear Becquerel radiation is capable of being deflected, at any rate partly, by a magnet. No decrease in it could be observed in about six months, but rather—as far as my observations go to show—an increase, similar to that in the case of radium. The degree of power of emanation of different preparations in the same chemical compound is proportional to the intensity of their Becquerel radiation. Igniting for a short time does not destroy the power of emanation.

Glass vessels in which the substance is kept phosphoresce, and on opening them the smell of ozone is perceptible.

The strong and rapid inducing effect of the substance is very striking. Most objects, e. g., paper, which are shut up in the same receptacle (as small as possible) with the substance, very soon exhibit the same characteristics as the substance itself. If the preparation wrapped in paper is held at the back of the platinum cyanide screen for half to one minute the spot in question becomes luminous for a short time. No luminosity appears on laying on the varnished side of the screen.* This induction was clearly produced, not by the Becquerel radiation of the preparation, but by the emanation; it can be regarded as an absorption of the emanation, and is thus more easily perceived in porous substances, such as paper. The moisture present in the substance plays an important part in it. Wet filter-paper is made more strongly and lastingly active than dry. Impregnation with aqueous ammonia or hydrochloric acid gives the same result as with water.

By means of a current of air the emanation can be extended, so that the usual screens if they are unvarnished or prepared with gelatin (which absorbs the fumes) are rendered luminous by it. The phosphorescing zinc sulphide is best adapted for this purpose. The current of air momentarily discharges an electroscope. A thin film of celluloid intercepts the emanation.

If the preparation is laid in a cylindrical metallic capsule, closed at one end, and this is held vertically with the opening downward toward a zinc sulphide screen negatively charged by an influence machine at a distance of from 5 to 10 centimeters from it, a diminished phosphorescence image of the opening of the capsule appears on the screen. This is brighter at the edge than in the middle. By inclining the screen, an elliptical instead of a circular surface is projected. A square opening gives an image in the form of a square with each of the sides slightly depressed in the center.

If the opening of the capsule is diminished to any desired form, e. g., by means of shaped shutters, very sharp, still more clearly and homogeneously luminous diminished images of the openings are obtained. The phosphorescent image so affects the screen that it becomes luminous for a long time, and gives secondary emanation. If the capsule is insulated, the image becomes fainter. A current of air, which only extends the secondary emanation, no longer influences the position of the image. Direct convergence of the "beam of rays" could not be established; only a grouping together apparently takes place; generally the image is smaller for greater distances between screen and capsule. If the image is approached by a conductor connected to earth, in consequence of the positive charge induced by the negative screen, repellence takes place. The image is deformed to a straight or semi-circular line, according to the shape of the conductor; the space between it and the conductor amounts to 1 to 2 centimeters. A dielectric rod held between the screen and capsule does not repel so energetically, and only casts an enlarged shadow. If a wire net connected to earth (which interrupts the electric field) is held in the place of the rod, the screen remains dark; on insulating the wire net the emanation penetrates.

All the phenomena are the same if the screen is negatively charged and the capsule connected to earth, or if, conversely, the capsule is positively charged and the screen connected to earth.

From these experiments it follows that the emanation experiences in the electric field an acceleration in direction from the positive to the negative electrode. The emanation changes into a radiation; it must itself possess a positive charge.

Up to the present, with the means at my disposal, I have not been able to perceive any effect caused by a magnet in the emanation, which is influenced by the electric field.

The question whether the emanation is to be regarded as the positive ions, and the new radiation as a parallel to the channel radiation, or S, radiation of E. Goldstein (Verh. d. Dtsch. Phys. Ges., 1902, iv., 228), or whether the emanation is simply the vapor of the substance itself, which, according to Curie's researches on radium, can itself assume a positive charge, may be left undecided. In any case, the emanation of my substance is very different from that of radium, which does not cause the phenomena described. I should suggest calling the new rays "E rays."

The measurement of the flame spectrum of radium Prof. Runge has most kindly undertaken. He will report on it in Drude's Annalen, 1903, ii., 1.

According to Profs. Runge and Bodländer, the gas constantly evolved from solutions of radium bromide is essentially hydrogen.‡

The following communication comes from Prof. Bodländer:

"The solution of 1 gramme of the 5 per cent radium preparation sent to me gave off 3.5 cubic centimeters of gas in sixteen days. Seventy-eight per cent of this gas was hydrogen, and 17 per cent oxygen, while the solution became colored brown by bromine. Thus a sort of electrolysis‡ occurs under the influence of the radium, in that the negative electrons change the hydrogen ions into neutral molecules, while by the positive electrons, bromine or hydroxyl ions are discharged. The experiments on the duration of the evolution of gas under different conditions will be continued, so that the source of the not inconsiderable energy (1.8 watt-seconds = 0.43 cal. = 18,000 g. c.m. daily) obtained from about 5 centigrammes of radium bromide may be explained."—Berichte der Deutsch. Chem. Ges.

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* Berichte, 1902, xxxv., 3608.

† The only temporarily active rare earths previously separated by me (Berichte, 1900, xxxiii., 3570, ; 1901, xxxiv., 2776) from uranium mineral, as well as from commercial uranium salts (Berichte, 1900, xxxiii., 1665) behaved in the same way as "ThX."

* In all researches I have paid attention only to the emanation when it can be observed on the zinc sulphide screen.

† Commercial thorium preparations do not affect the luminous screen.

* Only a pure radium salt with the highest activity produces a brief luminosity of the platinum cyanide, but it is immaterial which side of the screen is exposed to the radium.

† Two Geisler tubes which I had previously filled with radium gas (one with gas from solution and the other with gas from crystals) showed the hydrogen lines as plainly as possible. I did not then mention this, because it was not certain that the gas was absolutely free from water.

‡ Author's note.—The behavior of radium solutions discovered by me (Ann. d. Phys. u. Chem., 1899, lxix., 92) with regard to the radiation, as opposed to that of the solid salt, may be thus explained. The energy of the radiation is manifested in the solution more in the form of a decomposition of the water, and less as Becquerel radiation.

THE SERPOLLET STEAM AUTOMOBILE.*

I. ARRANGEMENT OF PARTS ON THE CHASSIS.

THIS article forms the first of a series descriptive of a steam automobile run by superheated steam generated in a so-called "flash" boiler. The entire machine, as well as the system of steam generation employed, is the invention of M. Leon Serpollet, who is the original inventor of the boiler in question, an adaptation of which has been so successfully used on the White steam carriage in this country. M. Serpollet has thrice won the Rothschild cup, presented to the automobilist who covered a kilometer in the fastest time from a flying start. His time this spring in the trials at Nice on April 4 was 29.19 seconds. A picture of his steam racer is shown herewith.

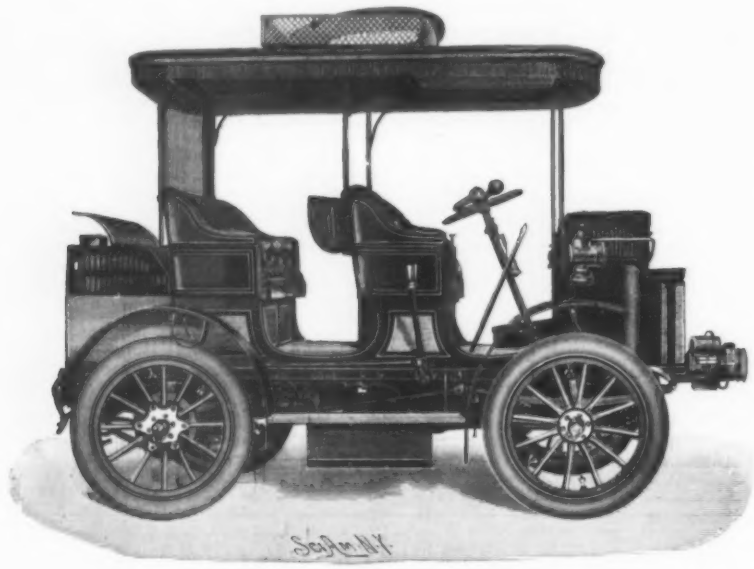


FIG. 1.—THE SERPOLLET 12 H. P. SURREY.

The 12 horse power surrey, or double phaeton, shown in Fig. 1, is a typical Serpollet car. The boiler and burner are situated beneath and back of the rear seat, the engine being under the center of the body, and driving the rear axle by a chain. The plan view of the chassis (Fig. 2) will give the reader a good idea of the general layout of the machine and the arrangement of its parts.

A is the gasoline tank in which air pressure is set up by means of a hand pump for first starting the burner, *B*, or for feeding it when the vehicle is standing. When the car is running, the small automatic pump, *p*, regularly forces the proper quantity of fuel into the burner through the pipe, *b*. *O* is the auxiliary hand water pump. This is connected to the water pipe, *c*, which regularly supplies the generator with water pumped by the automatic pump, *P*, that draws its supply through the pipe, *m*. When starting or climbing a hill, more water can be supplied by hand if necessary. *L* shows the driving cams of the fuel and water pumps, by shifting which with the lever, *K*, the stroke of the pumps may be varied, and more or less fuel and water supplied to the burner and generator, as desired. *E* is the oscillating arm moved by the cams and to which the pump plungers are connected. *R* is a spring for holding *E* in contact with the cams, while *k* is the rod connecting the cam-shifting lever with the handle, *L*, on the steering post.

The superheated steam from the generator, *C*, is conducted to the safety throttle, *F*, from which it passes to the engine through pipes, *J* and *K*. These pipes are all tightly jacketed with corrugated asbestos to prevent loss of heat from the steam. Oil is introduced into the cylinders through the nipple 4 of the cross 1, 2, 3, 4, the other three nipples of which are connected to the steam pipes as shown. *N* is the oil reservoir, and *S* the connecting rod operating the ratchet feed device, *Z*. The exhaust from the motor passes through the pipes *Q Q'* to the condensers, the ends of the tubes of which are seen at *V*. *X* is a cylinder for the storage of compressed air used in connection with the water storage cylinder, *Y*, for automatically introducing water into the boiler by simply opening a valve, when first getting up steam or when extra water is needed in climbing a hill. A small pipe, *x*, connects the two cylinders.

The letter *T* in both illustrations refers to the cam-shifting lever of the motor for varying the cut-off of the valves, together with its various rod connections and operating handle on the steering post. The horizontal motor employed is somewhat similar to a gasoline motor. It has four cylinders in opposite pairs, each cylinder having an inlet and exhaust valve operated by cams. A complete description of this motor will be given in a future issue.

Fig. 3 shows the dashboard of the Serpollet car, with the four gages, etc. Gage 1 indicates the air pressure in the gasoline tank, *A*; gage 2, that made by the automatic fuel pump; gage 3, the steam pressure; and gage 4, the pressure in the automatic feed-water cylinder (*Y*, Fig. 2). *F* is the brake pedal that applies the band brake *H*, Fig. 2, to the brake drums of the rear wheels. The other pedal, *W*, opens the throttle when depressed. The throttle is normally held closed by a spring. *D* is the valve that controls the flow of water into the generator from the pressure cylinder, *Y*, Fig. 2. *Q Q'* are the exhaust pipes leading into the condenser, *C*.

The construction of the throttle can be seen by referring to the diagram, Fig. 4. It consists of a round cast iron box in two parts, viz., a flat bottom part, *B*, in which is a circular groove, *i*, and a cover, *F*, on which is a rim, *j*, that fits in this groove when *F* is laid upon *B* and clamped tightly to it by bolts passing through lugs *e*, *g*, *h*.

The bottom part, *B*, of the throttle has a perfectly flat surface on its upper side, in which are two holes—a round one, *a*, and a heart-shaped one, *c*. These holes connect, the one with the entrance pipe, *W*, of the steam, and the other with the pipe, *I*, through which it makes its exit. The steam enters through *a*, which is always open, and fills the box. If *c* is open, the steam forms a head in the inner passage, which leads it to the cylinders of the engine through *I*. The valve that covers the port, *c*, consists of a button, *R*, on an arm, *M*, that a suitable lever, *M*, slides over the heart-shaped opening. The valve, *R*, is held against its seat by its own weight and by the pressure of the steam upon it. The port, *c*, is given its peculiar shape in order that the steam shall be admitted gradually to the cylinders at first. The valve should be kept either wide open or else closed, as it is not advisable to run with it half open.

The central plug, *f*, in the cover can be removed once in a while and a little gasoline injected to keep the valve from sticking, though this is a thing that very rarely happens, and then never more than once, sometimes when the vehicle is new. If anything gets disarranged about the throttle, the best way to do is to take it apart by removing the three bolts that clamp it together.

By the arrangement adopted, the car may always be left standing with safety and with the assurance that it will not start itself or run away unless someone meddles with and presses the throttle pedal.

(To be continued.)

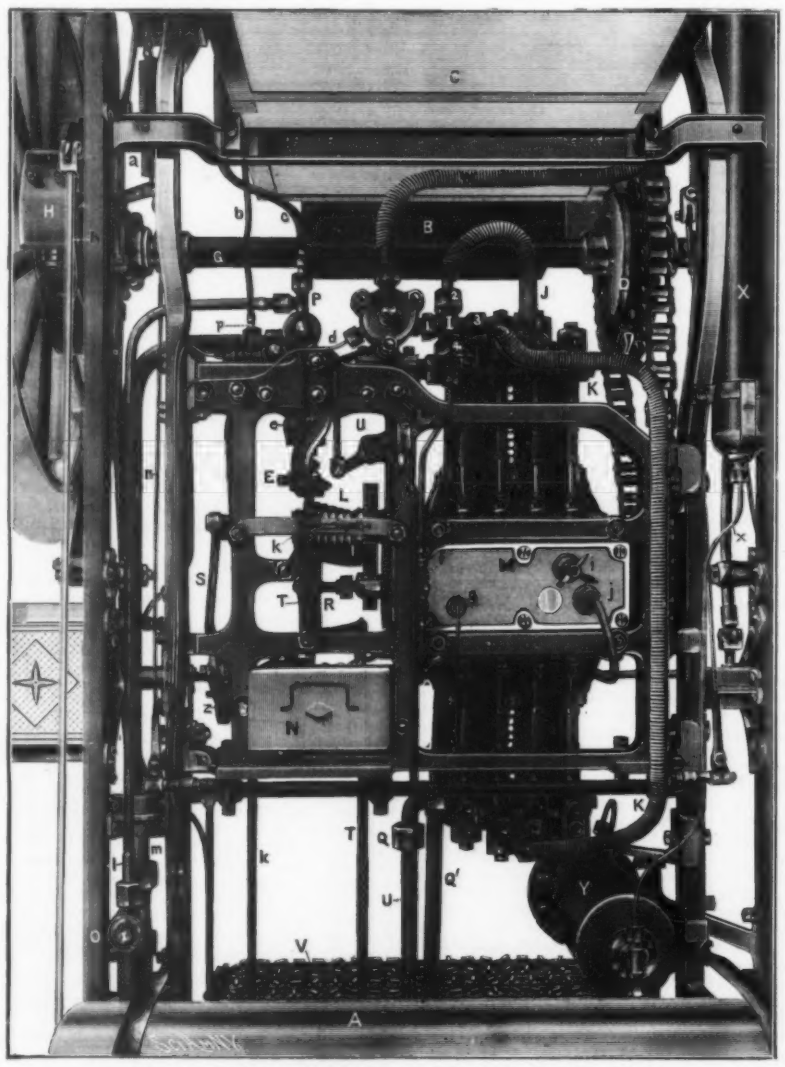


FIG. 2.—PLAN OF CHASSIS OF SERPOLLET CAR.

* Article specially adapted for the SCIENTIFIC AMERICAN SUPPLEMENT from a description of the Serpollet automobile published in La Locomotion.

[Concluded from SUPPLEMENT No. 1427, page 22871.]

REPORT ON A VISIT TO AMERICA.

By Lieut.-Col. H. A. YORKE, R. E., Chief Inspecting Officer of Railways.—Board of Trade, London.

II.—SURFACE LINES, SUBWAYS, AND ELEVATED RAILWAYS.

SURFACE LINES.—I examined the surface lines and tramways in a great many cities, viz., New York, Brooklyn, Washington, Boston, Pittsburg, Detroit, Buffalo, Toronto, and Chicago, and was interested to find that grooved girder rails—such as are invariably used in England—are being almost universally adopted for lines in the public streets, in place of the "step" rails formerly employed. The latter are a serious hindrance to ordinary vehicular traffic, though they are said to be convenient to heavy lorries, and for this reason are retained in some of the streets in Boston and Pittsburg. As a rule street railways are electrically equipped on the overhead trolley system, but in New York and Washington the conduit system with center slot is used, there being objections to the overhead system in the streets of those cities. In all cases the rails are laid upon cross ties, concrete being as a rule placed between the ties, which does not seem to be the best place for it. The use of wood for supporting the rails makes a much quieter track than the English method of laying the rails direct on concrete, but the American method does not enable such a good surface to be maintained on the roadway. English tramways often have a hard and noisy track, and it might be an advantage if a wooden stringer or cushion were placed between the rail and concrete—at any rate an experiment in this direction would be worth trying.

In some cities rails 60 feet long are used, and as by this means the number of joints, which are invariably a source of trouble, is reduced by 50 per cent, considerable benefit may be expected from their adop-

tion. A similar experiment might with advantage be made in England.

American cars are all single decked, there being no roof seats, but they are wider and generally longer than English cars. I also think that as a rule they have more powerful motors than are usual in England, which is an advantage, as the motormen have greater control over their cars. Speeds in the city streets are about the same as in England, but in the suburbs are higher than are usual here The lifeguards are indifferent, and accidents are numerous, though no records are obtainable on the subject. As a rule the hand-brake only is used, though in Pittsburg, where grades are severe and speeds high, the Newell magnetic slipper brake is fitted to the cars, and is in regular use. This brake is, I believe, a most useful appliance. It consists of a "slipper" which is practically a horseshoe magnet, and which is energized by current from the motors, when the latter are acting as generators, i. e., when the current from the trolley wire is cut off. Care must be taken not to cause the wheels to skid by means of the hand brake, and when the wheels cease to revolve no current is generated by the motors and the magnet is not energized. In Chicago the Christensen direct air-brake is adopted, but here three and four cars are allowed to be coupled together.

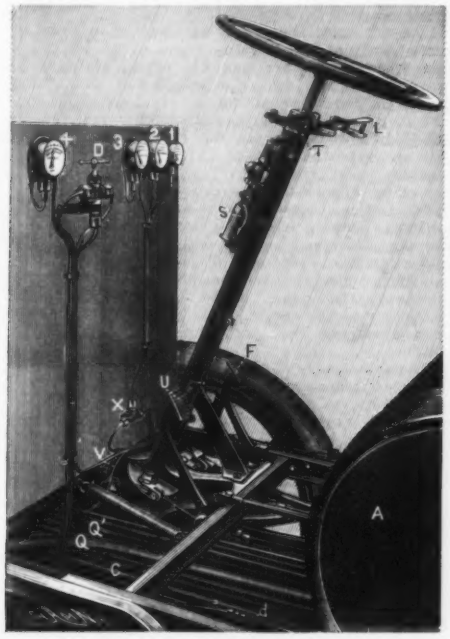


FIG. 3.—DASHBOARD, SHOWING GAGES AND CONTROLLING LEVERS AND PEDALS.

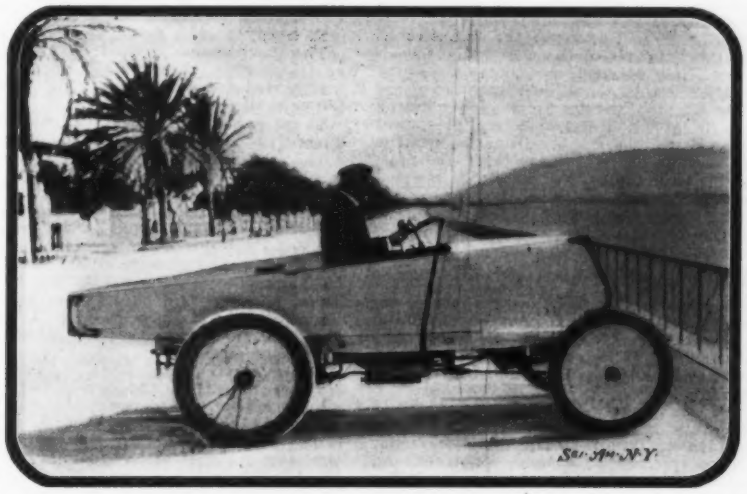
Elevated Railways.—Of the elevated railways of New York, Brooklyn, Boston, and Chicago it is not necessary to say much, as they are not likely to be imitated in any English town. They are noisy and unsightly, and the columns supporting them occupy a great deal of street space and constitute a hindrance to street traffic. They are all, with the exception of that in New York, operated entirely by electric energy at 550 or 600 volts, the current being conveyed by a third rail. In New York the elevated railway has hitherto been worked by steam locomotives, but electric traction is being rapidly introduced, and both steam and electric trains are now running on it. It is expected that when the electrical equipment of this line is completed, its capacity will be largely increased, owing to higher speeds, more rapid acceleration, and the use of longer trains.

The Boston elevated lines are equipped with automatic (electro-pneumatic) signals, and with triggers working in conjunction with the signals, whereby the brakes are applied to any train which is allowed by the motor-man to pass a signal at danger. The equipment and organization of this line, and the arrangements at certain stations for enabling passengers to change from the tramcars to the railway or *vice versa*, are particularly good.

All trains on the elevated lines are of the multiple-unit type, the master controllers being either of the Sprague, Westinghouse, or General Electric Company's pattern, for each of which special merits are claimed. Fairly high speeds are attained, but the numerous sharp curves on all these lines, due to their following the directions of the streets, are a serious drawback.

Subways.—The most recent attempt to solve the problem of urban locomotion is to be found in the subways of New York and Boston, each of which is the outcome of Special Rapid Transit Commissions appointed, in the one case by the State of New York, and in the other by the State of Massachusetts—the former in 1894 and the latter in 1891. These commissions studied the problem of transportation in and around the cities named, and made specific recommendations for the construction of subways to accommodate either two or four lines of rails, the routes to be followed and the sums to be spent being in each case laid down. It was decided that the New York subway should be worked as a railway, two tracks being reserved for express traffic, and two for local traffic. At Boston it was first intended to devote all the tracks to the use of the surface (or tram) cars. This was subsequently changed, and where four tracks exist two are now given up to the trains from the elevated railway and two to the surface cars. This change of plan was unfortunate, as the grades and curves in the subway, which are suitable for single cars, are found to be detrimental to the trains, causing not only delay, but also undue wear and tear of the wheels, rails, and rolling stock.

As a rule these subways are rectangular in section, but that in New York is now being extended under the East River, by means of a "tube," the internal diameter of which is 15 feet, 6 inches. It is much to be regretted that the "tubes" in London have not been constructed of similar dimensions. The cost no doubt would have been greater, but if the method of financing these works in America had been adopted in London, the increased cost would not have been felt while the advantage gained would have been great.



LÉON SERPOLLET ON HIS 40 H. P. STEAM RACER THAT WON THE ROTHSCHILD CUP.

The cost of the Boston subway was borne by the city, and the Boston Elevated Railway Company, which owns the surface and elevated lines, leases the subway from the city, paying 5 cents for each car passing through, subject to a minimum payment of 4¾ per cent on the cost of construction. The lease is for 20 years. The company laid the tracks and supply the power and equipment.

The cost of the New York subway is also borne by the city, the Rapid Transit Subway Construction Company being the contractors for the work, and having a lease of 50 years for operating the subway when completed. The contracting company is paid for the work in accordance with their tender, but has to pay in its turn a rental equal to the interest on the bonds issued by the city to provide the funds for the work, and in addition a sinking fund of 1 per cent by which the principal will be redeemed within the period of the lease. The company has to provide equipment, power, and machinery, which the city is to purchase at a valuation at the end of the lease. This arrangement is similar to that under which the Chemin de Fer Metropolitan of Paris is being built. The advantage of such an arrangement is that, at the end of the period of the lease, the railway is paid for, and becomes the property of the city free of cost. There seems no reason why some similar arrangement should not be arrived at in London.

The commissions referred to are permanent bodies, and all schemes affecting transportation within the limits of their respective cities have to be submitted to, and approved by, them. For instance, the proposal of the Pennsylvania Railroad Company to construct tunnels under the harbor and East River, so as to enable their main lines to obtain access to New York city, had to receive the sanction of the Rapid Transit Commission of New York.

The three cities Paris, New York, and Boston, afford an object lesson to London. They have faced the problem of urban communication in a businesslike fashion, have decided what they want, have arranged for the financing of the work, and have settled the routes along which transportation is to be provided, before allowing the ground to be broken, instead of proceeding in a haphazard fashion, and leaving the most valuable concessions to be scrambled for by private companies. It is much to be hoped, if I may be permitted to say so, that a tribunal will be appointed before it is too late, to consider the congestion of the London streets and to propose a remedy.

The subway in New York is still incomplete, and will not be opened for traffic before the year 1904,

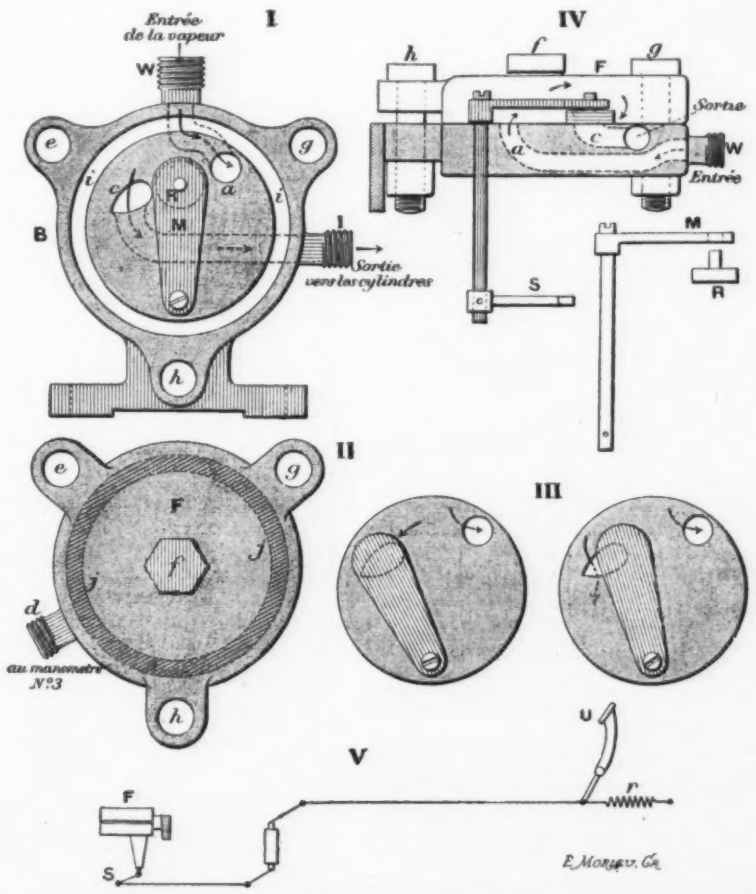


FIG. 4.—PARTS OF THROTTLE VALVE AND DIAGRAM SHOWING CONNECTION WITH PEDAL.

but that in Boston has been in use since 1898. In both cases the subways are as near the surface of the streets as possible, and have, as in Paris, convenient stairways to afford access to the stations, no elevators being therefore needed. Such subways are in many ways preferable to deep level "tubes." They are safer, more easy of access, possess a purer atmosphere, and

afford conveniences to the public, which are worth considerable sacrifices to attain. What New York has cheerfully suffered and is still suffering to obtain its subway, has to be seen to be believed.

New York has one advantage over London, in that the city is built almost entirely upon rock, and no disturbance is therefore to be feared of the foundations of existing buildings. On the other hand, this rock, which is intensely hard, renders the work of excavating the tunnel a most costly and tedious undertaking.

In one respect I anticipate that the subway will prove a disappointment to the inhabitants of New York, for although it will increase the facilities of travel between the outskirts of the city and the business centers, it will not do much to relieve the congestion of traffic in the streets. It will mitigate the undue crowding of the cars on the tramways and elevated railway, which is at all times uncomfortable, and occasionally even dangerous, but it will not reduce the number of vehicles in the streets, as there are practically no omnibuses and very few cabs to be affected by it. In London the case would be different, as the construction of a subway or "tube" is sure to cause a diminution in the number of 'buses plying along the same route.

III.—ELECTRIC (HIGH SPEED) INTERURBAN RAILWAYS.

Of all the developments of facilities for transportation, the interurban lines, which are now such a prominent feature in the United States, are the most interesting and instructive. These are becoming increasingly numerous, every city having a network of such lines radiating from it.

I am not now referring to the mere extensions of the street tramways into the country, though these might be regarded as interurban in their character, but to lines of heavy construction and equipment, and specially designed for high speeds. In some instances the lines are branches of the main railroads, which have recently been equipped for electric traction. But in the majority of cases the interurban lines have been specially constructed for operation by electricity.

Among branch railways, originally built for steam trains, but now operated electrically, may be mentioned the following examples, which are to be found on the New York, New Haven & Hartford Railroad, but there are many others:

(1) Stamford to New Canaan, 8 miles of single track.
(2) Hartford to Bristol, 16.6 miles of single track.
(3) Berlin to New Britain, 3 miles of double track.
(4) Braintree to Cohasset, 11.5 miles of double track.
(5) Nantasket Junction to Pemberton, 6.9 miles of double track.
(6) Providence to Fall River, 18 miles, of which 10 miles are double track.

The first of these to be equipped electrically was the line from Nantasket to Pemberton, in 1895. The New York, New Haven & Hartford Railroad found at that time that the trolley lines were seriously affecting their revenues, and in order to meet this competition they decided to equip some of their branches electrically. The result of doing this to branch No. 5 was so satisfactory that the process was extended to the other branches, some of which had up to that time been worked at a loss.

The following table, compiled from the most recent available returns, was given to me, and shows the increase of annual passenger traffic due to the change:

Branch.	Steam. Passengers.	Electricity. Passengers.
1	98,300	184,728
2	367,695	1,060,617
3	267,936	341,207
4 and 5.....	304,292	702,419

This large increase in traffic may be attributed to the greater frequency of the service, the reduction of fares, and the increase in speed.

Branches 2, 3, and 4 are equipped with the third rail; the others have the overhead trolley. The trains consist of two to five cars, and are run at a schedule speed of 30 miles per hour, with an average of one stop per two miles, the maximum speed being 45 miles per hour. The weight of a motor car is 45 tons, and its seating capacity is 60 passengers.

On the Providence & Fall River Line the trains consist of one, two, or three cars, there being 112 of such trains daily. The service is both local and express, the running time of the local trains with 26 stops, being 45 minutes, which is equal to a schedule speed of 25 miles an hour. The express trains with seven stops cover the distance in 33 minutes, which is equal to a schedule speed of 32.7 miles an hour.

The old steam schedule between Providence and Fall River was 48 minutes for local trains with 14 stops, and only 10 trains per day, and there was no express service.

The rolling stock of this branch consists of 46 cars, of which 24 are passenger coaches used as trailers, and nine are combination baggage and passenger cars, the remainder being motor cars. The cars are 40 feet in length over all. The motor cars have four 80 horse power motors, and weigh 30 tons.

The wheels on the motor cars are 36 inches in diameter, having a 1¼-inch flange and a 3-inch tread. The rail used weighs 78 pounds per yard, and the road bed has gravel ballast. The population of Providence is 175,000, and that of Fall River 104,000, and the average daily traffic is 15,000 passengers, the fare for the whole distance being 20 cents, which is half the whole steam fare.

The above description affords a good idea of the results obtained by the operation of unremunerative branch lines of main railroads by electricity.

Of High Speed Interurban railways specially built for operation by electricity, I visited four, viz.:

(1) The Schenectady & Albany Railway.
(2) The Buffalo & Lockport Electric Railway.
(3) The Detroit & Port Huron Shore Railway.
(4) The Aurora, Elgin & Chicago Electric Railway.

(1) The Schenectady-Albany line is a high speed overhead trolley railway, 17 miles in length, between Schenectady and Albany, 4½ miles of which are within the limits of the two cities. It is a double track located on the public highway, the district between the termini being rather sparsely populated. The population of Albany is 100,000, and that of Schenectady 50,000. The average schedule speed is, for the whole journey, 18 miles per hour, with nine interurban stops, and about 22 city stops. The schedule speed between the cities is 27 miles per hour, and the maximum speed is 50 miles per hour.

As a rule single cars are used, weighing 24 tons each, and with a length over all of 48 feet. They are equipped with four 50 horse power motors, and have a seating capacity of 52. The motor truck wheels are 33 inches in diameter, with ¾-inch flange and 2⅞-inch tread, the axle being 4½ inches in diameter.

The transmission current is three-phase alternating at 11,000 volts, the greatest distance to which it is transmitted being 17 miles. The working current is 550 volts direct.

There is a 15-minute service between the two places during the day and evening, and an hourly service during the night. The number of passengers carried is about 3,700 daily, the single fare being 25 cents (1s.), and the double fare 40 cents. The New York Central has a steam railway alongside of the electric line, the passenger traffic on which has been greatly reduced since the latter was opened. The fare on the steam railway is 39 cents single ticket. It takes about 55 minutes on the electric railway to travel from the center of Albany to the center of Schenectady, and 40 minutes on the steam railway, but the smaller fare and the frequency of the service render the former the more popular route.

There is an "express," i. e., baggage and parcel, service, and a freight service on the electric road, separate cars for the purpose running every hour, the gross tonnage carried averaging 1,043 tons per month.

The tracks are laid with 80-pound T-rails on crossties, and are well ballasted. They occupy about two-thirds of the width of the public highway, and though the company possesses no exclusive right to any portion of the highway, the mode of construction of the railway, and the elevation of the rails above the road practically deprive the public of the use of so much of the roadway as is required for the railway. Probably no great inconvenience is experienced on this account, as the highway is unmetaled, and is little used for vehicular traffic. The advantages conferred on the public by the railway more than balance any inconvenience due to its presence.

(2) The Buffalo & Lockport Electric Railway is an overhead high speed single track trolley line 25½ miles in length, of which 12½ miles are within city limits. The motor cars are 42 feet long over all, and are fitted with four 50 horse power motors. There are also some 30-ton electric locomotives used for freight service, which haul ordinary freight cars, and which are equipped with four 160 horse power motors.

The schedule speed for interurban running is 27 miles an hour, and the maximum is 50 miles an hour. The round-trip fare from Buffalo to Lockport and back is 75 cents (3s.).

The line is operated by the International Traction Company of Buffalo, which also owns the electric railway between Buffalo and Niagara, etc. The current is derived from the Niagara Falls Power Company.

(3) The Detroit & Port Huron Shore Railway is a single track road with passing loops, having a total mileage, including lines within city limits and passing loops, of 110 miles. It is a trolley line laid, so far as I saw it, alongside the highway, and endeavors have here been made to interfere as little as possible with the use of the highway for its original purpose.

The power station is at New Baltimore, about 32 miles from Detroit, and the current is transmitted to a distance of 40 miles in one direction and 20 miles in another. The transmission current is 16,000 volts, and there are five sub-stations equipped with 200 kilowatt converters from which the trolley current is supplied. Most of the cars are geared for a maximum speed of 45 miles an hour, some with two motor equipments and some with four. The freight cars have four motors. Fifty passenger cars and 25 freight cars are in service.

Detroit is now the center of about 400 miles of interurban railway, and much valuable experience has been gained here in the operation of this class of line. As the various lines were originally the property of different companies a great variety of construction is to be found. Nearly all the lines are now under the control of the Detroit United Railway Company, who are engaged in establishing a uniform system of equipment and operation.

(4) The Aurora, Elgin & Chicago Railway is one of the most recent and most important undertakings of this class yet constructed. The total length of route is about 60 miles, the greater portion of which is double track. The line is built entirely upon the company's own land except at public road crossings, the width of land occupied being from 100 to 60 feet. It is laid throughout with 80-pound steel rails in 60-foot lengths, with 2,640 ties to the mile. It is operated on the third-rail system, the conductor rail weighing 100 pounds per yard, and being of a special description of soft steel. The top of this third rail is 6 3-16 inches above the top of the running rails, and it is placed 19½ inches outside the track. The track is most substantially constructed so as to be suitable for very high speeds, the regular maximum speed being intended to be 65 miles an hour, while 80 to 100 miles an hour can, it is anticipated, be made with safety. Experiments with such speeds are to be made next spring, after the roadbed has had time to become thoroughly consolidated. The power house is at Batavia at one end of the line, and there are six sub-stations. The transmission current is 26,000 volts 3-phase alternating, and is carried by aluminium stranded cables, on poles placed alongside the tracks, the same poles also carrying the telephone wires. The traction current is 600 volts direct, and no direct current feeders are needed, as the third rail has sufficient carrying capacity to conduct all the current needed from the sub-stations to the trains in the different sections of the line.

The trains consist of one, two, or three cars. The one and two car trains have every axle motor-driven; the three car trains have one car without motors. The cars are 47¼ feet over all. Those carrying motors are of extra strength in the sub-frame, and have four 125 horse power motors, the most powerful equipment ever put on a motor car, other than those used on elevated railways, where the motor cars act as locomotives to haul several trailers. The wheels are 36 inches in diameter, and have Master Car Builders standard flanges and treads. The axles are 6½ inches in diameter, being the largest yet used on an electric car. The trains are expected to attain a speed of 50 miles an hour in 25 seconds starting from rest, a performance never before attempted in electric railway practice.

In most cases the traffic on interurban lines is conducted by means of train orders given by telephone. The train dispatcher has his office located in some convenient spot, and the telephones are placed in cabins or booths or in the sub-stations along the line. The train orders from the dispatcher are received at the telephone cabins by the conductor or motorman, and are repeated back to the dispatcher by the man receiving them, the other man standing by and hearing them repeated. The orders are all received verbally, and no record is kept of them. No car is permitted to leave a telephone station until such an order has been received and repeated. This method seems to be cumbrous and out of date. On single lines the use of the electric train staff or tablet would be simpler and quicker, and would, I believe, add largely to the safety of the traffic. The instruments should be of such a nature that they could be operated by the conductors.

By the courtesy of the Chief Engineer of the General Electric Company I have particulars of several more interurban railways similar to the above, but enough has been said to show what great developments are taking place in this respect in the United States. Such lines are becoming of increasing importance, population becomes more numerous in their vicinity, land values are enhanced, industrial enterprise is stimulated, and the convenience of the public is served by a frequent and cheap means of transportation not only for passengers, but also for freight. Farmers are said to appreciate the facilities thus afforded them for conveying their produce into the cities, and large quantities of milk are now daily carried into the markets by electric cars. Where steam railroads exist side by side with the electric lines, the competition between the two has been keen. Steam roads having seen a large share of their passenger business taken from them, have made a hard fight to retain the local freight business. But it would appear that the increased prosperity and activity in a district, which are promoted by the presence of an electric line, result in bringing more business to the steam lines. So that while the electric lines will probably carry the local traffic, passenger and freight, for short distances, they will act as feeders for the through business of the steam roads. In other words, there is a place for each, and their interests are best served by working in harmony.

The experience gained in America in regard to electric interurban railways should be of great value to those engaged in the construction of similar lines, under the name of "light railways" in this country. American engineers have discovered that "a modern first-class electric railway should have a location that will admit of the most direct route with as few curves as possible, and be so laid out as to curves as to have them as easy as possible." It has been found not only desirable but "most economical to purchase private rights of way," to use heavy rails, large ties, and plenty of good ballast. Experience has proved that a substantial, well laid track is a "vital factor" in the economical operation of such a road, and a "large factor" in its earning capacity. The question of the best type of car for such railways is still receiving much attention in the States, and has not yet been finally decided, but it is found that a heavy substantial vehicle is necessary, and that the wheels should have deep flanges, broad treads, and strong axles. In some instances, as for instance on the Schenectady-Albany line, the depth of the flange is limited by the grooved rail over which the cars have to run within city limits, but where high speeds are aimed at, safety requires that the wheels and wheel flanges should be similar to those employed on fast steam roads.

In England the electrical interurban railways, which have been constructed under the Light Railways Act of 1896, differ in every respect from similar lines in America. They are almost invariably laid alongside the high roads, have light rails, and insufficient ballast, while the cars employed on them are mostly double-decked and have tramway wheels with small flanges. Such lines are nothing more than tramways, and quite unsuitable for high speeds. If railways of this nature are to be as successful here as they are in America, their owners must, I venture to think, profit by American experience, and follow American methods.

Descriptions of many other objects of interest will be found in my diary, and need not be repeated here.

In conclusion I have to express my grateful acknowledgments to my numerous American and Canadian friends, who did all in their power to make my visit to their country enjoyable and instructive. The President of the United States, to whom I paid my respects, gave me a friendly welcome, and all with whom I came in contact, without exception, spared neither time nor trouble to assist me in my inquiries, and to make me feel at home. Wherever I went I was cordially received, and invitations were tendered to me to extend my tour through the whole length and breadth of the country, of which, I hope, I may be able to take advantage on some future occasion.

I have the honor to be, sir, your obedient servant,
H. A. YORKE, Lt.-Col., R. E.

A Dead Black Varnish for Wood.—The varnish that camera makers use is made as follows:

Water	8 ounces
Borax	30 grains
Glycerin	30 minims
Shellac	60 grains

Heat slowly until the shellac is thoroughly dissolved and then add nigrosine, W. S., 60 grains. This latter is one of the best aniline blacks.—Inland Printer.

CROSS-FERTILIZATION IN SOCIOLOGY.*

By J. COLLIER.

INDIVIDUAL FERTILIZATION.

IMMIGRANT individuals initiate or continue the work of groups or masses. A few striking examples may be as convincing as a long list. Dynasties are often founded by immigrants. A Suabian cadet founded the house of Hohenzollern, and his type of character has proved persistent through all alliances, manifesting itself as plainly in the present vigorous ruler as in any of his ancestors. By a kind of moral transfusion the solid qualities of the race have passed into the people, which is likewise marked by courage, prudence, thrift, simplicity of life, a firm grip of reality, and a total estrangement from German dreaminess and confused vision of reality. With these attributes kings and people together have expanded a slender nucleus into a powerful state, and made that state the heart and brain of Germany. A single woman carried into France in the sixteenth century the impure blood of the Medici. Keen observers have detected in the portraits of her sons the prepotency of the strong Italian house over the brilliant lineage of Francis I. Is it possible to mistake the same prepotency in the history of the following reigns? At a time when France was wavering between Catholicism and the Reformation, Catherine and her sons assured the predominance of the old religion. Corsican Napoleon re-made France in his own image. The Cisalpine house of Savoy built up the Transalpine kingdom of Italy. Noble families, too, have introduced a new strain into their adopted country. The German Colonnas in Italy were long and strenuously anti-Papal; the Savoyard Colignys nearly succeeded in carrying France over to Protestantism; the Italian Broglies, though doubly crossed with Protestant houses, have, on the whole, exercised a reactionary influence in France; the Savoyard Sainte-Aldegonde was the author of the Compromise of Breda with which began the war of independence in Holland; and another Savoyard, Bonnivard, heralded the reformation in Switzerland, and the independence of his country. Great statesmen have sometimes given a new political complexion to their adopted country. Mazarin saved the unity of France. Beaconsfield added prestige to Imperialism, and created a new England that some of us no longer know. The Duc de Richelieu was the founder and ruler of Odessa. Bolivar was no Peruvian. Political leaders, such as Kossuth and Strossmayer, were foreigners. Great discoverers, from Columbus to De Brazza, are often foreigners. Four Danes excited original developments in Prussia. Repaying the debt of France to Maurice of Saxony, Moltke made advances in the art of war that assured victory to Prussia and afterward to Germany. Niebuhr created a new historical method, to which Mommsen gave ascendency. George Brandes has acclimatized cosmopolitan criticism in Berlin. The arts have everywhere been transmitted by immigrant artists. Two examples will perhaps serve where hundreds could be given. Lulli, with the aid of Quinault, founded Italian opera in France, and from their joint product descends the characteristically French opera. Gounod's "Faust." Spontini carried Italian melody to Germany, and there married it to the German genius for harmony, represented by Weber, and from these two have sprung Mozart's "Don Giovanni," and the more characteristically German operas of Wagner. An equally pointed instance will show how cross-fertilization acts in science. The Italian astronomer, Cassini, made in Paris the first observation for measuring the earth. In company with the Abbé Picard he began the tracing of the first meridian, which Picard continued, and from the measurement of the degree given by Picard, Newton calculated the force that retains the moon in her orbit. The more recent names of Tadema and Herkomer, of Panizzi and Libri, Mohl and Max Müller, out of hundreds in all countries, will suggest how much all departments of human activity are fertilized by blends. Sometimes immigrants merely strengthen an existing tendency. The Saxons Ranke and Treitschke, transplanted to Berlin, became "more Prussian than the king," and the Suabian Hegel buttressed Conservatism in the same country. Lastly, prelates like Bessarion and Ximenez, and such monarchs as Francis I. and Louis XIV., Isabella of Spain and Catherine dei Medici, the Czar Peter, the Czarina Catherine, and Frederick the Great, who import artists, men of letters, and savants, resemble the botanists who place the pollen of one plant on the stigma of another, or the breeders who artificially pair varieties.

DEGENERATE MODES.

We have already passed insensibly into a new order of facts. Fertilization by masses and groups was brought about by the actual mingling of two stocks. Fertilization by individuals is often physical; the Colignys and the Colonnas, the Savignys and Chopins, the Roscoes and Rossettis, are the offspring of crosses between immigrants and natives. But many immigrants of genius are either celibate or sterile. Mazarin, Disraeli, and Moltke were pure-bred, and though all three left behind them offshoots of their race, they themselves added not a drop of alien blood to their adopted countries, any more than did the host of missionaries, from Mahinda and Boniface to Moffat and Damien, to the countries they evangelized. Their action was purely spiritual. Spiritual action is the mimicry of physiological action; nevertheless, it too is genuine. A thinker's thoughts, an artist's works, a statesman's deeds, are as children born to him, and the transformation they accomplish becomes physiological in turn. The modes of cross-fertilization still to be described are of this order.

The female of many animal species goes in search of the male, or at least throws herself in his way. From Plotinus to Postel, and from Burnouf to Mrs. Besant, sages, scholars, and seekers have gone on pilgrimage to the East to discover the secrets of existence or the materials of science. Medieval students flocked to Paris, and the fertility of Scholasticism is doubtless due to the German, Italian, and English crosses with the French intellect. Young Castilians southed to Granada to learn courtly manners, as the young English used to do the grand tour, and Spanish ceremony may owe its stateliness to the instruction. The English, French, and German scholars of the Renaissance pilgrimaged to Italy. Painters and sculptors of all countries frequented Rome, as now Paris. New species are thus begotten. Again a few examples must suffice.

Almost all the pre-Revolutionary thinkers of France had visited England, and had studied its constitutional liberties, its science, philosophy, and free-thought. Montesquieu spent two years in our country, and every page of his chief work bears witness to the fertility of the contact. Voltaire came to England "to learn to think," and passed three years in constant intercourse with its greatest writers. His debt to English thought has perhaps been overstated. M. Brunetière has conclusively shown that Voltaire's skepticism was of earlier date than his visit to England, and in fact he but continued an old French tradition. But it cannot be doubted that his native tendencies were stimulated by acquaintance with Bolingbroke and English deists. Not less fruitfully he became the expositor of the Baconian logic, the Newtonian physics, and the Lockian psychology. English notions of liberty and canons of criticism passed into the French mind. Mr. Lecky does not exaggerate in describing this interaction as the junction of the French and English intellects.

The Baptist of the modern renaissance of art was Johann Joachim Winkelmann. A deep affinity for Hellenism in both intellect and temperament led him to the study of Plato, the inspection of casts from the antique at Dresden, and finally to Rome. There he accomplished his "finding of Greek art." All who have since transfused the old Hellenic spirit into literature and faith, art and life, descend from him. No more scientific language than Hegel's can be used to describe his generation of a new variety:

"By contemplation of the ideal works of the ancients, Winkelmann received a sort of inspiration through which he opened a new sense for the study of art. He is to be regarded as one of those who in the sphere of art have known how to initiate a new organ for the human spirit."

Under the gray skies of Sweden, Fogelberg, like Mignon, dreamed of the South. A dying Swedish sculptor told him that in Italy alone he should find true beauty. He had sought to achieve a Balder, a Thor, an Odin, and had failed; he needed the fertilizing contact with Greek art. After some years' study in Italy he produced an Odin, which Gustave Planche describes as the offspring of "a happy alliance between the Swedish genius and the antique genius." It is a new type, a genuine creation. His Thor and Balder are similarly two original types, neither Greek nor medieval, whose conception is Scandinavian, while the expression is Greek.

Thorwaldsen spoke of himself as having been born on the day he entered Rome, when he was twenty-seven years old; till then, he said, he did not exist. The influence of Rome transformed a skilled artisan into a sculptor. His principal merit, according to Vicomte Delaborde, lay in combining the ancient style with modern sentiment. He expressed modern ideas and new or revived themes according to Greek methods, discovered by intuition and not by learning. He went back to an earlier period of Greek art than had previously been imitated, and, with an irresistible force of assimilation, he incorporated its substance and penetrated its spirit. Michel Agniolo had, in just the same way, founded the sculpture of the Renaissance. More consciously and systematically, Flaxman and Ingres arrived at similar results.

The extent to which this mode of cross-fertilization still prevails in scholarship will appear from the fact that, in 1900, over 2,500 foreigners were entered on the books of the German universities. Of these 736 were Russians, in whom the ardor of conquest is equaled by the ardor of discipleship. The Russians are at once female to higher and male to lower races.

SECONDARY AGENCIES.

1. The insects, birds, and mammals that carry pollen and seeds to other plants and countries, have their analogues in the chapmen and traveling merchants, navigators, pilgrims, and missionaries, who convey books, works of art and industry, germs of religious ideas and political movements. It is a degenerate mode of fertilization, being far slower and less efficacious than the local presence of immigrants, but its facts are identical. Native species are modified, if less deeply, and new species are transplanted, though they, too, undergo modification. An ancient and a modern example may be adduced. Phœnician merchants undesignedly introduced into Greece the Egyptian alphabet and art of writing, and thus founded the culture of Europe. The first seeds of Christianity were planted, half unconsciously, by the pirate-merchant Vikings, who returned to Scandinavia after a long sojourn in Christian lands.

2. The winds and marine currents that likewise transport seeds have their congeners in the world-rivers and commercial routes, and their analogues in the ships, caravans, and vehicles by means of which the bulk of modern propagandism is accomplished. Wind-fertilized plants are believed to be degraded specimens of insect-fertilized plants, and the intellectual influences conveyed through books and casts, though often vivid and powerful, are faint in comparison with the direct action of teachers immigrant or resorted to. Two illustrative instances might be developed were there space: (1) New England transcendentalism was begotten by the writings of Coleridge, Cousin and Carlyle on the theology of Puritanism as expounded by profound thinkers like Jonathan Edwards. None of its inspirers ever visited America, and, if Emerson visited Coleridge and Carlyle, he professed that he derived little benefit from personal intercourse with either of them. Yet New England transcendentalism is a distinct variety of philosophic thought. (2) Darwin never visited Germany, and few Germans were received at the modest house in Down; yet Darwin's writings initiated a new and fruitful movement in that country to which no bounds can be set. Darwinism developed by Haeckel is, again, a distinct variety.

From these few examples alone we might conclude that "nature abhors self-fertilization" in civil as in natural history, and that no sociological species, as no biological species, is perpetually self-fertilized. Where a nation, like the Chinese, maintains its vigor intact for centuries of refusal to cross, it owes its tenacity to being one of the most widely migratory peoples on record. Dispersal over a large area may protect a species against its own exclusiveness.

* Knowledge.

SUITABLE FERTILIZERS IN THE CULTIVATION OF LETTUCE.

MARKET-GARDENING is everywhere developed in the suburbs of the large cities, and nowhere more than in the outskirts of Paris, and even within Paris itself near the fortifications. Lettuce, in its numerous varieties, is the object of special attention. For some years the forced cultivation of this plant has occurred along the Mediterranean shore, and in the lower valley of the Rhone (Vaucluse, Gard, and Ardèche) in immense tracts.

M. Beaucaire, in his study of various plants, has ascertained the true requirements of lettuce with reference to nutritive principles. He filled a number of pots with washed and sterilized sand; then put several seeds in each of them on the 25th of March. On the germination of the seeds, from the 6th to the 12th of April, he left but a single plant in each pot. Each received a different fertilizer, with the exception of one left for comparison.

These are the results obtained in the weight of seed:

	Gr.
1. No fertilizer	0.5
2. Farm manure	9
3. "Complete" fertilizer	11
4. "Complete" fertilizer, special	12
5. Nitrogen and phosphate	10
6. Nitrogen and potash	6
7. Potassium phosphate	2

The flowering and the gathering took place in the following order respectively: (1) August 20-September 15; (2) August 12-September 17; (3) August 15-September 12; (4) August 16-September 11; (5) August 20-September 18; (6) August 18-September 20; (7) August 20-September 21.

The lettuce in the sand without fertilizer fared badly; although it was sprinkled with a solution of ferric sulphate, most of its leaves grew yellow; it had no branches and presented the appearance of the worst vegetable misery.

The farm manure produced a good effect. The lettuce grew to a reasonable height and had numerous leaves, green and firm; only there were few branches, and they became too strong.

Pots 3 and 4 behaved better in all respects; the lettuce which they contained was perfect.

No. 5 having no potash, the development of the stalk of the lettuce was not favored.

No. 6, lacking phosphoric acid, had still less opportunity, and finally, the plant in No. 7 was invaded by worms, which mercilessly devoured almost all the roots. Was this in consequence of the absence of nitrogen? The experiment in this case does not appear to be conclusive.

M. Beaucaire, commenting on the results, says that lettuce, in order to produce seeds in quantity, needs a soil rich in nitrogen, and that phosphoric acid is more useful than potash. He adds that ferric sulphate prevents the plant from yellowing and facilitates fructification. A 5 per cent solution is recommended when the flowers begin to appear. It destroys the larvæ, which would devour the seeds after their full maturity. This was applied by him on August 19. In his note to us he says: "Lettuce, like endive, being subject to cryptogamous maladies, it is well to make use of a preventive solution when the stem commences to appear." The market-gardeners, as well as those who cultivate lettuce for pharmaceutical purposes, will do well to give heed to this disinterested counsel.—Translated from Le Phosphate.

COTTON GROWING.

ACCORDING to the London Times, there is a strong anxiety among the Lancashire cotton manufacturers to be less dependent upon American supplies of raw cotton.

Sir William McGregor, governor of the British colony of Lagos, West Africa, has been in Egypt to study cotton growing with a view to introducing the cultivation into Lagos. The governor of Sierra Leone is also stirring in the matter. He told the British Cotton Growers' Association a few weeks ago that he could depend upon native chiefs to supply the labor and he would do all in his power to promote cotton growing in his colony.

As we look over the field there seems little prospect as yet that the great manufacturing countries will depend less upon the supply from our cotton fields than they do to-day. Cotton growing in tropical Africa is as yet in the early experimental stage. It has thus far been a failure in East Africa. The experiment in Toga Land with American cotton seems to promise better results.

Russia has long desired through her Central Asian fields to become independent of our supplies, but her hopes are vanishing. The Ferghana crop is large and excellent, but nature has placed a limit upon it. No more cotton can be raised than can be irrigated. The limit of the water supply is in sight and there is no hope of cotton growing beyond that point. Similar conditions limit the Egyptian crop; and, besides, the prospect is now bright that in a few years our country will be a formidable competitor of Egypt in growing Egyptian cotton on our own lands.

India would be our most serious competitor if it were not for the fact that its staple is very short and cannot be used for the fine yarns which are the crowning excellence of the British industry. Brazil grows long staple cotton, but its methods of raising the crop, preparing it for market and transporting it to the seaports must be revolutionized before its product can be very prominent in the world's trade.

Cotton growing on a large scale requires plenty of suitable land and great capital; and there is no part of the world that is likely ever to fulfill these condi-

tions so admirably as our own vast cotton areas, much of which are not yet utilized. If our cotton fields are ever to meet with serious competition it will be so far in the future that we may leave the worrying to later generations.

HOLLOW PRESSED AXLES.*

By CAMILLE MERCADER, Pittsburg.

THE axle is one of the most important elements used in rolling stock. Upon its strength depends the safety of the whole car superstructure, and upon its freedom from friction the economy in draft. While improved forms of construction have been devised in every branch of the railroad equipment, the axles for tenders and cars have been rather neglected, and this portion of the equipment has only kept pace with the other improvements by increasing its size and weight to gain the strength necessary for supporting the greatly increased loads which are now considered standard. A few years past, who would have thought of 110-pound rails, 125-ton engines, 175,000-pound steel cars and the many other improvements now considered necessary for the economical operation of our great railway systems?

It is a well-recognized fact that steel articles manufactured by pressing are, as a rule, superior to articles made by any other method, and the present tendency is to develop this method in every branch of the iron and steel trade, especially as it insures the most economical production of articles needed in considerable quantities and makes them perfectly true and uniform to the templet, permitting interchange of parts or the making of standard sizes. The writer proposes, in the present paper, to present, briefly, an account of the development in the manufacture of railroad axles on a large scale which was successfully demonstrated and accomplished at the Homestead Steel Works of the Carnegie Steel Company, Pittsburg, Pa.

In order to produce, by pressing, an axle having varying diameters, the following method was proposed by the writer: A rolled round steel blank, uniformly heated, is inserted into a two-part die, having a matrix cavity in the form of a rough turned axle. The diameter of the journals is made equal to the smallest diameter of the axle in the center, which corresponds to the diameter of the round blank. After the dies are clamped about the heated round the latter is axially perforated simultaneously at both ends by two cylindrical punches, which force the metal of the blank to conform to the shape of the matrix die and fill out the same. The round is heated up to about 1,000 deg. C. and the total hydraulic pressure required for penetration with a punch of 3 inches diameter amounts to about 50 tons. During the last end of the stroke a total hydraulic pressure of about 150 tons is required because the blank loses its initial heat through contact with the dies and because the end collars upset, at which time the metal may flow back against the punch.

The experiments performed at Homestead gave evidence that the lower limit of temperature for successful punching was reached at about 850 deg. C., as near as could be judged. At this temperature the punch entered with difficulty, requiring about 250 tons initial pressure and about 500 tons final pressure for upsetting the collars; the metal, however, filled out the die very nicely producing a fair looking axle. At a temperature of about 950 deg. C. the pressure required at the end of the stroke amounted to about 250 tons, and at about 1,050 deg. C. a pressure of about 150 tons was found to be sufficient.

In testing these axles Pennsylvania Railroad drop test specifications were followed, viz., seven blows at 43 feet of 1,640 pounds weight, striking midway between supports 3 feet apart; axles to be turned over after every other blow. The axles, having stood this test, were subjected to further blows until destruction, with results as follows:

"A."—Axle Blank Punched at 850 Degrees C.

Weight of axle, 710 pounds; diameter of center, 5⅞ inches; size of journals, 5½ inches.

No. of blow.	Deflection. Inches.
1	5⅝
2	6
3	4
4	5⅝
5	4
6	5½
7*	4

* This seventh blow fulfilling the Pennsylvania Railroad requirements, the tests were continued to destruction, which occurred at the 72d blow.

This test was most severe, the axle being turned over after every other blow.

The steel had the following analysis: Carbon, 0.39 per cent; phosphorus, 0.024 per cent; manganese, 0.47 per cent; sulphur, 0.026 per cent.

"C."—Axle Blank Punched at 1,050 Degrees C.

Weight of axle, 700 pounds. Dimensions of axle same as before.

Axle was turned over after every other blow, the test being most severe.

No. of blow.	Deflection. Inches.
1	3⅞
2	4 11-16
3	3 3-16
4	4¾
5	3⅛
6	4 9-16
7*	3 1-16

* This seventh blow fulfilling the Pennsylvania Railroad requirements, the tests were continued to destruction at the 37th blow.

The analysis of the steel was: Carbon, 0.54 per cent; manganese, 0.67 per cent; phosphorus, 0.03 per cent.

The steel was too hard, having an excess percentage of carbon and manganese, which is also shown by the small deflection after the first blow in the drop test. After rupture which occurred at the center, the two halves of the axle were weighed and the difference in weight was only 2 pounds, demonstrating the exactness of the shape and the uniform compression throughout the axle.

It is safe from these tests, to derive the conclusion that by determining the proper temperature for punching the hollow pressed axles for railway rolling stock can be made of superior quality. These axles are found to have much greater strength than the usual solid axles and the metal is more homogeneous, owing to the internal and external forging exerted upon a thin wall thickness.

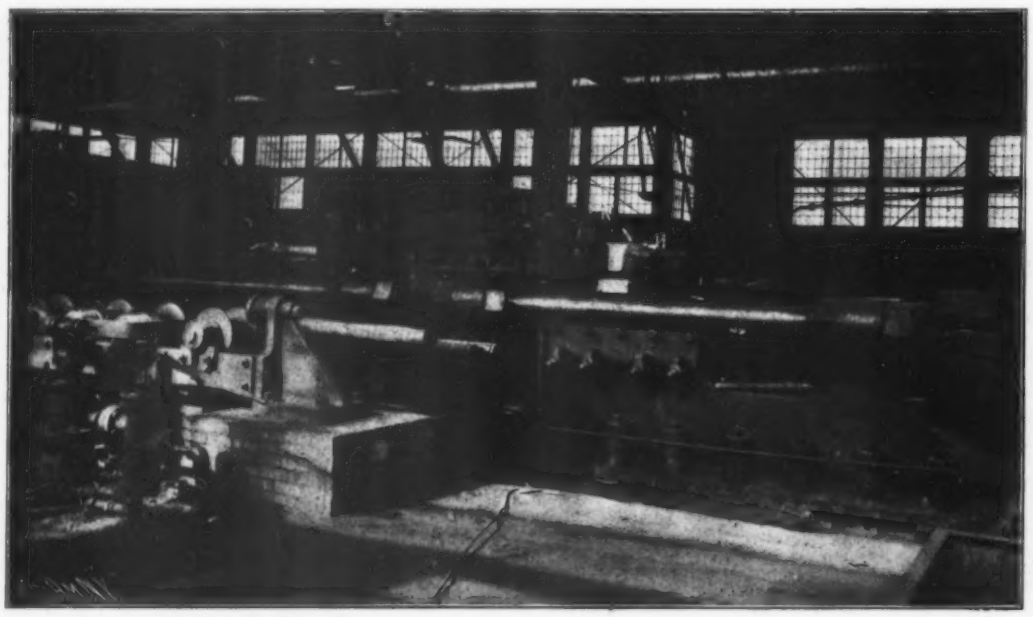
CENTER OF HOLLOW PRESSED AXLE.

CENTER OF SOLID FORGED AXLE.

JOURNAL OF OIL-TEMPERED HOLLOW PRESSED AXLE.

In order to demonstrate the practicability of manufacturing railroad axles on a large scale by means of punching, an experimental machine, designed by the Carnegie Steel Company, was erected at the Homestead Works, according to accompanying drawings. In the accompanying drawings *P* represents the punching and the upsetting press, having two dies, 2 and 3, between which the metal blank is clamped and shaped. The dies have a matrix cavity, giving approximately the shape of the finished axle. The two upsetting punches, 4 and 5, are adapted to enter the matrix cavity longitudinally, being guided by a cross-head, *D*, and moved in a longitudinal direction by the plungers, 6, of hydraulic cylinders 7. The punches are made sufficiently long and the plunger is given a sufficient stroke to enable them to penetrate the axle blank lengthwise beyond the wheel seat of the axle. The blanks are heated in a continuous furnace of the Howard Axle Works type. Between the furnace and the press is a straightening machine, composed preferably of a pair of cross rolls, driven by two 100 horse power electric motors. These rolls are adapted to receive the blank, cause it to traverse longitudinally and rotate, and by such travel and rotation straighten and round the blank perfectly. The diameter of the cross rolls being unequal, the blank is pressed against a bottom guide placed the entire length between the rolls, thus removing all scale and delivering the blank to the press with a clean and smooth surface. A feed table conveys the blank to a position opposite to a lateral transfer device, 13, composed preferably of inclined skids and of a tilting frame, 14, which may be operated by a hydraulic cylinder, 15. When in this position the axle blank is stopped by coming into contact with a buffer, 16, whereupon the frame 14 is raised and the straightened blank is caused to roll down upon the bottom die 3, which is movable laterally upon a slide, so as to carry the blank under the upper die of the press. During its passage to the die the blank is guided at its ends by guides, 17, which center it lengthwise to suit the die cavity. To effect the lateral or traveling movement a lateral track, 18, is provided, upon which are mounted slides, 19, and upon which the die head 3 when in its lowest position rests and by which it is engaged. These slides are connected by a cross-head, 20, and gearing, 21, to the piston of the hydraulic cylinder 22, and by the operation of this cylinder the slides carrying the die head and the dies are moved back and forth to the positions shown in the drawing. 23 and 23 are wedges which are mounted under the operative position of the die head and are moved by hydraulic cylinders, 24, forwardly underneath the die head, in order to support and lock it when elevated. The lifting of the die head 3 is effected by the plunger 25, which is set directly beneath the operative position of the die head, the axle blank being gripped and held thereby at the center and at the journals. To retain the dies in this position and to withstand the outward pressure exerted during the foregoing operation, the wedges 23 are projected under the die head. The dies 2 and 3 being thus locked by the wedges, the piercing punches 4 and 5 are brought into engagement with the ends of the axle blank, whereupon said punches penetrate the blank, pass beyond the wheel seat portions and displace the metal of the axle blank outward, so as to fill the cavities of the dies, forming the wheel seat and taper of the axle of the proper size and contour. The rear portions of the punch engage the ends of the axle blank and force the same inwardly toward the die cavity, and thus, by compressing them, shaping up these ends and forming the collars. The forging of the axle is then completed and it only remains to remove it from the machine and subsequently to turn the journals and wheel seats.

With the experimental plant erected in Homestead the time required to make one axle, all operations included, did not exceed two minutes. Allowing, again, two minutes for cleaning and black leading the dies and for cooling and capping the punches, the capacity of one press will be 15 axles per hour, or 300 axles, 5½ x 10 inch journal, per 20 hours, which is fully three

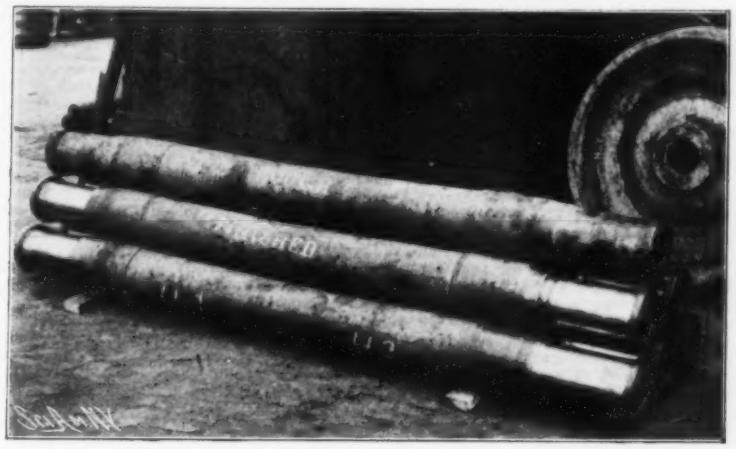


MERCADER HYDRAULIC AXLE PRESS.

* A paper read at the May meeting of the Iron and Steel Institute.

times the quantity accomplished with one hammer by the best American practice. The number of men required to operate the press remains the same as needed at the hammer to forge five 5½ x 10 inch journal axles per hour. The machine above described has many advantages. It is effective in construction and produces a strong and light axle which contains the cardinal combination desired—namely, minimum weight and maximum strength.

Axles made as above set forth have more resiliency than the present type, and are not, therefore, liable to fracture from sudden strains. Their use in railroad



MERCADER HOLLOW PRESSED AXLES

car construction results directly in material economy, not only over solid axles, but over any other species of hollow axles known to the writer.

Broadly speaking, hollow axles are old, but such axles have been made either by casting them the shape desired or pressing them hollow throughout and then forging on a mandrel or by boring out solid metal. These methods are each objectionable, because they either fail to produce axles of sufficient strength and lightness or are too expensive for general adoption. The end portions of this axle are, of course, hollow, the cavities extending beyond the wheel seat, but this is an advantage because the forging action which is produced by the entrance of the punches greatly compacts and strengthens the metal and renders the axle less liable to break. The combination of hollow ends with solid center has the advantage over hollow axles that all requirements for the drop tests and for torsion, produced in curves, are fully covered. It is obvious that a hollow axle will soon deform in the center under the drop test, rendering the test uncertain.

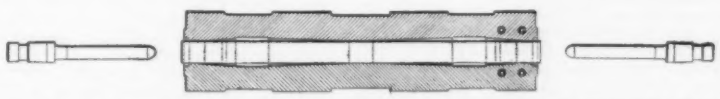
The various tests made can be regarded as remarkable, putting at rest any suspicion that the axles are unsound in any particular part; for example, at the junction of the solid and hollow part. The breaking of the axles always in the center demonstrates beyond doubt that the use of the hollow ends with a solid body combines all the qualities and advantages of both a solid axle and a hollow axle, the resisting power being almost equal to a solid nickel-steel axle.

The etched disk specimens shown in the accompanying photographs were prepared to illustrate these points. The disks were cut from the portions of the axles as indicated, and after polishing, were etched with 5 per cent sulphuric acid for ten hours.

The disk from the journal of the solid axle shows in the center practically the same grain which existed in the blooms as it came from the rolling mill, and on the edges a very much finer appearance where the work from the hammer has penetrated. This fine grain is not equidistant from the outside at every point, but has an oblong shape, the greatest depth corresponding to the edges of the bloom (7½ x 8½ inches) as is also shown in Diagrams 3 and 4.

The disk taken from the center of the hollow pressed axle shows a much more uniform grain, corresponding to the finer portion of the solid forged axle. In the neighborhood of the center the grain is slightly coarser. In the case of the disks cut from the journals from the ordinary (cooled in air) and the oil-tempered hollow pressed axle, the grain is practically the same, with a very fine grain extending inward a short distance from each surface. These illustrate the first point as regards work, and show that the hollow-pressed axle is very much superior to the ordinary solid forged axle.

Microscopic specimens show that the regions of the axles near the surfaces have a much finer structure than in the center, except in the oil-tempered axle, which is very uniform throughout. In the case of the solid forged axle, the outside was penetrated by the work to only a comparatively slight depth, and being cooler than the interior (due to the air and the cold hammer and die) has a fairly fine structure,



THE TWO PUNCHES, AND THE BLANK IN POSITION WITHIN DIE.

while the center shows that due to the highest temperature to which the bloom was heated. The hollow-pressed axle received work all through it, but as the portions coming in contact with the die and punches were cooled to a certain extent, they were worked at a lower temperature than the center, which was very nearly as hot as when it came out of the furnace. Since the oil-tempered axle was *reheated* to above the critical point (to 760 deg. C.) it shows a structure corresponding to that temperature. The oil-tempered

best adapted to resist the strain to which it is subjected with the least amount of metal, combining minimum weight with maximum strength.

2. The forging effect being carried out throughout the material, both internally and externally, the material is found to be far more homogeneous than solid axles made in the usual manner, segregation is destroyed, and, consequently, the axle is much more reliable.

3. The journals, being highly compressed, will in finishing attain a more highly polished surface, thereby minimizing the friction, resulting in economy of draft.

4. The journals, being hollow, will remain cooler and permit the storage of a considerable quantity of oil, removing herewith the chief cause of hot journals, also economizing materially in the expenditure for lubrication.

5. No straightening after punching is required, the axle being as straight as the die, thereby eliminating entirely the injurious effects of the gagging operation.

6. No centering, no cutting of the ends, no rough turning is required, thereby saving considerably in finishing labor and increasing the finishing capacity of existing plants.

7. The punching of treble the amount of axles as compared with forging with an equal number of hands, resulting in saving of forging labor.

8. Considerable saving in steam consumption and fuel.

9. The detection of a defective axle without performing any extra work—that is, without the necessity of rough turning it over all, which provision is now included in the latest M. C. B. specifications.

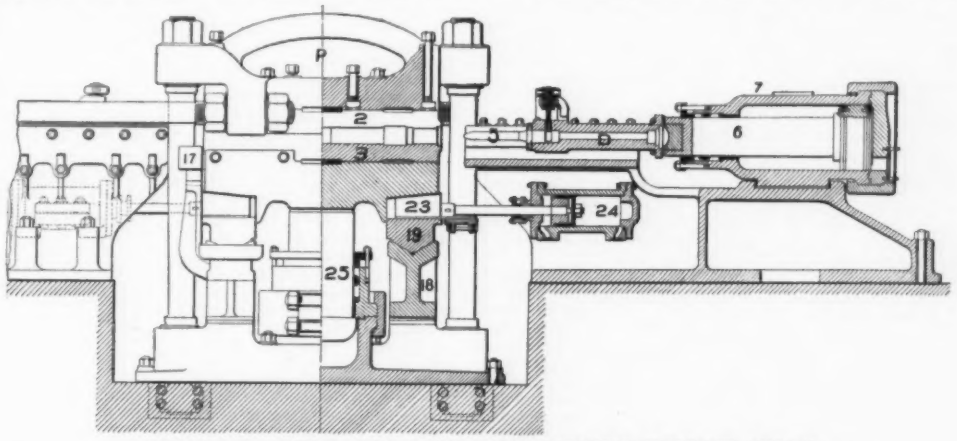
10. Approximately uniform fiber stresses throughout the body of the axle, due to the straight and uniform taper between the wheel seats.

11. A saving of 33 per cent of steel in the manufacture.

12. Present drop test specifications need not be changed.

13. The possibility of supplying uniform axles, limiting the weights and dimensions to a minimum.

14. The weight of a 100,000 pounds capacity steel car is decreased by 1.7 per cent, permitting this load, which amounts to 24,000 pounds in a train of 40 steel cars, to be carried without any additional expenditure of energy. Converting this advantage into other channels, there would be a corresponding saving in coal consumption or tractive power.



SECTIONAL VIEW OF MACHINE FOR FORGING HOLLOW AXLES.

AN INVESTIGATION OF A GARBAGE CREMATORY.*

THE base of the furnace is placed one story below the street level, so that the garbage can be readily delivered from the street to the floor level above the furnaces, and easily be fed to them through openings in the floor. The furnaces and feeding floor are inclosed in a brick building, apparently well and strongly built. The crematory is of the Davis type, and consists of two complete garbage furnaces connected by separate flues to a single chimney stack. The chimney is built of brick, has an internal section of 5 feet square, and is about 120 feet high above the base and about 100 feet above the entrance of the flues. In the stack are a set of screens of ½-inch mesh, for the purpose of intercepting dust and larger particles escaping from the fires, and also a regulating damper which can be operated from a point near the feed hole.

Each furnace consists of:

1. An arched drying chamber, 8 feet square and 8 feet 6 inches high to the key of the arch, into which the garbage is dumped through a feed hole. It is provided with grates, chiefly for drainage purposes. The garbage remains in this chamber during the process of draining and drying, and at intervals it is raked down with long iron rakes into the combustion chamber.

2. An arched combustion chamber, 4 feet long, 6 feet wide and 4 feet high to the key, placed in front and approximately at the same level as the drying chamber. It is provided with grates on which coal is burned to assist the burning of the garbage which the attendant rakes down from the drying chamber.

3. A main flue about 3 feet wide by 3 feet 6 inches high, leading from the furnace to the chimney stack.

4. An arched secondary flue, 4 feet 6 inches long by 5 feet 4 inches wide and 3 feet high, in which is situated a set of fire grates about 2 feet long and 4 feet wide, and on which auxiliary fires are kept burning ostensibly for the purpose of completely eliminating odorous fumes on their way to the stack.

5. A so-called evaporating pan, under and of the same area as the drying grate, into which the liquid from the garbage freely drains. Some of this liquid may be evaporated, but most of it is led off by a 4-inch drain pipe to the sewer in the street.

6. A feed hole or opening above the drying chamber, through which the garbage is dumped. It is closed with a movable iron cover.

7. Grate bars, about 4 feet long and 4 inches wide, the openings between which are ½ inch wide for the fire grates and ¼ inch wide for the drying grate.

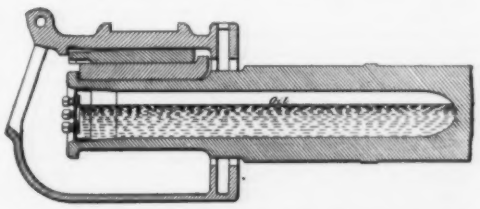
8. Ash pits undel all grates, and firing and observation gates or doors complete the chief parts of the installation.

The chimney stack, the furnaces themselves and their parts appear to be built of good material and indicate good workmanship. The station appeared to be kept clean and in good order.

The City's Refuse.—The city's refuse may be classified as follows:

1. Ashes, bottles, cans and other non-combustible material, which is collected and disposed of by tipping and filling at various places in the city.

2. The garbage proper or house refuse, being largely of combustible nature and also known as "swill" or "slop," containing at the present season much fruit and being almost saturated with water, is collected and delivered at the crematory by the city in special garbage carts.



HOLLOW AXLE USED AS OIL RESERVOIR.

3. Garbage and refuse from stores, markets, etc., is collected and brought to the crematory by private

* Extracts from a report by Rudolph Hering to the Special Committee on Crematory of the City Council of Trenton, N. J.

parties. Much of it is of a very combustible nature, such as paper, rags, straw, wooden boxes, etc.

The collection and disposal of the first of these classes, apparently not causing any trouble, has not been considered in this investigation. The disposal of the garbage and refuse mentioned as the second and third classes has been a cause, however, for serious complaint, and to this the investigation is limited. Speaking generally, the sources of the troubles complained of may be stated as follows, and are subsequently discussed under separate headings: 1. Collection of garbage and odors arising from it when delivered at the works. 2. Odors from the ashes after their removal from the furnace when retaining some incompletely burned material. 3. Dust of completely burned garbage escaping from the stack and depositing in the neighborhood. 4. Unburned or still burning particles of garbage escaping from the stack and depositing in the neighborhood, with the possibility of falling upon shingle roofs or inflammable material and thereby causing fires. 5. Odors due to the unburned gases escaping from the stack.

Collection of Garbage and Odors Arising When Delivered at the Works.—The city garbage is collected in iron cars of approved make, holding about one ton and drawn by two horses. The carts collect from all parts of the city, daily except Sunday, and between the hours of 6 A. M. and 6 P. M. Each one serves a certain district, the number of trips being of such frequency that each house is visited as many as two or three times each week, according to the season. The carts are watertight, sanitary in every way, and so far as we know have not given any offense. The private garbage and dry refuse is brought to the crematory in the ordinary store wagons. We were not made aware that such collections had given any offense. The dry refuse, such as paper, wood, rags, etc., is generally collected from the houses in large bulk, while the garbage proper is first put into pails, boxes or barrels, usually left open, and subsequently collected by the teams.

On arriving at the crematory the contents of the carts and wagons are immediately dumped into the furnaces, unless these are already charged to their full capacity, in which case the wagon is detained or left standing until one of the furnaces is in a condition to receive the charge.

The only odors which may arise from the present method of city collection, can be caused by the often improper and usually open receptacle, but chiefly by the occasional filling of the cart beyond the normal capacity, so that the lids do not close, and odors may be given off while the carts pass along the street. The same objection may apply also to the private wagons for collecting garbage, but so far as we know, complaints have not been made.

These sources of trouble are easily prevented by proper municipal regulations and due care. Among the other essentials to prevent offensive odors from arising before the material is subjected to the burning process, are frequent collections of the garbage in proper vehicles, both of which you have already provided for very satisfactorily.

Odors from Ashes After Removal from Furnace When Retaining Some Incompletely Burned Material.—Offensive odors arise when the ashes are removed from the grates and deposited in exposed places before the garbage is thoroughly burned. This trouble is especially likely to occur with a crematory like yours, located in the midst of a thickly-settled district where such odors are more readily noticed than in remote districts.

On the day of our first visit to your crematory there was a strong odor emanating from the pile of clinkers or ashes which had been dumped in front of the building. An examination showed that it was due to quite a number of unburned pieces of animal and vegetable refuse. This annoyance cannot occur if the garbage is so thoroughly consumed upon the grates that nothing but clinkers and ashes remain when their removal from the furnace is necessary.

The remedy for the defect is therefore clear. 1. The furnace must be in a condition to be capable of completely burning the organic matter, of which more will be said below. 2. The attendant must be very observant and attentive in not pulling out anything but thoroughly burned material.

This inattention has at other places been a frequent cause of objectionable results and therefore of complaints. Too generally it is supposed that any stoker or fireman quite familiar with handling coal fires is also able to handle garbage fires. The latter, due to the presence and mixture of the greatest variety of combustible and non-combustible matter, are very much more difficult to operate than simple coal fires. When starting the furnaces in Hamburg, the most extensive garbage plant in the world, and also the experimental furnaces in Berlin, it was found necessary to import firemen from England, where crematories have been in use for fifty years, in order to train the German firemen in the special art of garbage cremation. It is an art that requires experience, skill, and a faculty for constant attentive observation, which can be acquired only under skillful guidance by continued practice of intelligent and faithful men.

Dust and Burned Garbage Escaping from Stack and Depositing in Neighborhood.—When garbage is carefully burned and the combustion is complete, there may yet be trouble from the fine ashes of paper, wood, rags, and other organic matter escaping from the stack and being carried with the wind to greater or less distances, even entering windows and causing dirt and consequent annoyance.

This nuisance is chiefly due either to faulty design of the flues or chimney, or to improper manipulation of the draft, or to both. In fact, ashes should not be carried up into the stack at all, but be deposited in enlarged flues or dust chambers on the way to the stack. These chambers should be given a relatively large sectional area, in order that the velocity of the fumes may be retarded and the heavier dust particles settle out, thus leaving practically the gases alone to pass freely out through the stack.

Even if the flues and dust chambers are properly designed, improperly designed dampers or their careless manipulation may also be the cause of this trouble. Dampers should have the full size of the flues, and be provided with simple mechanism so as to be easily operated from the fire-room or from a point near the feed hole. They should be always closed when the feed hole is open for charging the furnace, and also whenever the furnace doors are open for the purpose of firing, stoking, or cleaning. That is, they should be almost tightly closed, leaving only enough draft so that fumes do not rise into the building from the feed hole or furnace doors. In general, they should always be under such careful control and so manipulated that the velocity of the gases in the settling chamber and the flues can be maintained below a certain required maximum rate. What this maximum rate should be, permitting the dust particles to settle, we are not able to state with desirable definiteness, because the data are meager concerning such deposit, which depends upon the size of the particles and their specific gravity; the finer and lighter the particles of course the more readily they are kept afloat in the moving gases.

It may, however, be safe for practical purposes at present to estimate that the velocity of the current through the dust chamber should be kept as low as from 1 to 1.5 feet per second. In order to secure this reduced velocity, we must first know the volume of gas which passes through the dust chamber in a given time. It is a variable quantity and depends on the chimney draft and the manipulation of the dampers. With the proper grate area for the burning of thirty tons of garbage per day, we may, however, roughly estimate the volume of air required for the combustion as being about 150 cubic feet per second. This would therefore require a sectional area of at least 100 square feet, or more than four times the combined area of the present flues. To facilitate further the deposition of dust it is an advantage to have the level of the inlet as far as possible below the level of the outlet, so that the force of gravity, slight as it would be, can favor rather than hinder the tendency for the dust to deposit.

The construction of a dust chamber of ample dimensions, placed between the furnaces and the stack, and properly designed dampers, would very materially, and with careful manipulation in accordance with the momentary conditions of the openings at the feed hole and gates, probably wholly, remedy the defect discussed under this heading. The chamber should, however, be constructed with a sufficient number of baffles to secure a uniform reduction in the velocity, not allowing the gases to pass through more quickly in the center than along the sides.

Unburned Particles of Garbage Escaping from Stack.—The effects of completely burned particles of garbage escaping from the stack have just been described. The annoyance from the partly or wholly unburned particles now to be considered is more aggravated, owing to their charry or greasy nature, and, as they are heavier, also to their tendency to settle more quickly and therefore more densely in the immediate neighborhood of the crematory. There is forthcoming the possibility of still burning or glowing particles setting fire to roofs or to inflammable material in the streets or yards.

To determine the extent of this nuisance, careful observations were made, and it was observed, almost without exception, that particles of black charred paper and similarly light material escaping from the stack could be seen at intervals during a whole day. They were apparently more numerous shortly after the furnace doors or the feed holes were opened, which naturally causd an increased draft through the flues and chimney. The damper, which is supposed to be closed during the feeding of garbage to the furnace, was not always operated with the necessary ease during the days of our inspection.

To determine how far-reaching this nuisance was in the neighboring districts, observations were made at distances of one-quarter, one-third, and one-half a mile from the crematory, during one afternoon when the conditions appeared to be normal. The day was clear, and the wind was blowing at an estimated rate of about ten miles per hour. At a distance of one-quarter of a mile from the stack, about fifteen charred particles were observed in ten minutes to pass a plane at right angles to the direction of a moving smoke. At a distance of about one-third of a mile about ten particles passed in ten minutes, and at a distance of two-thirds of a mile two particles passed in ten minutes. The size of these particles varied from one-quarter of an inch to three-quarters of an inch square, averaging probably less than one-half an inch square.

Further observations were made by selecting places in fields, where the ground was sufficiently open to aid one in finding particles which might have previously settled on the ground. These places were selected always in the line of the moving smoke. The sizes of the particles were about the same as those first mentioned. At a distance of about two-thirds of a mile from the crematory, and after searching for about fifteen minutes, two charred particles were found on an area of fifty feet square. At a distance of one-third of a mile, after the same interval, eight particles were found on an area of about fifteen feet square. For how long a period these particles had accumulated cannot be stated. As a heavy rain had fallen during the previous night, sufficient in all probability to destroy traces of particles previously deposited, and as the wind had been in the same quarter only during the afternoon, it seems probable that these particles were the accumulations of only a few hours.

Observations were also made regarding the escape of burning embers from the stack. They were best undertaken at night, while the crematory was yet in full operation and when the burning particles were readily visible. On each of two nights, and extending over periods of from two to three hours, the burning particles from the stack were closely watched with the following results: 1. No embers were seen in a flaming condition. 2. Glowing embers were generally emitted after opening of the furnace doors for firing, cleaning or raking down the garbage. 3. During these times it was estimated that an average of fifty to one hundred sparks were emitted per minute. Of these it was further estimated that fifty per cent did not travel in a glowing state more than 25 feet from the top of the stack, ninety per cent not over 50 feet, ninety-five per cent not over 75 feet, ninety-nine per cent not over 100 feet, and rarely one could be seen 150 to 200 feet. From these observations it is evident that the trouble from escaping particles of unconsumed garbage is a serious one, and worse than if merely burned dust escaped from the stack.

In seeking for means to remedy this defect, we must carefully inquire into its two prime causes, namely, the incomplete combustion in the furnace and too great a velocity of the fumes in the flues.

Odors Due to Unburned Gases Escaping from Stack.—The stench resulting from incomplete combustion is usually the most serious trouble that arises from garbage cremation, and it is the one which in our country does not seem to have as yet been completely solved at any one of the principal garbage furnaces. It is in my opinion, in addition to what has already been said, largely due to the design of the furnace.

A fruitful discussion of this subject must necessarily be divided into a careful examination of: 1. The character of the material delivered, its composition, moisture and combustible matter. 2. The essential parts of the furnace to obtain a complete combustion of such material. 3. The manipulation of charging, discharging, regulating drafts, etc.

1. The Material Delivered.—The burning quality of garbage depends principally upon three things: the amount of combustible material which it contains, the amount of fine material or dust, chiefly of an incombustible nature, which fills the pores and obstructs the free access of air, and the amount of moisture. Garbage which is poor in combustible material will not readily burn under any conditions, and garbage though rich in combustible material may yet be so filled with moisture as not to burn without previous drying, or the interstices may be so completely filled with fine ashes or dirt that combustion is retarded and even prevented by the lack of air.

In European cities, where garbage and city rubbish is mixed also with ashes, the combined refuse is comparatively dry, and the percentage of unburned coal in the ashes, together with the combustible matter of the garbage itself, is sufficient in properly constructed furnaces to burn without the addition of fuel. In our country, however, there are many cities, as Trenton, where it has become the practice to separate the ashes and the garbage. The burning then may become a more difficult matter and ofttimes can only be accomplished by the addition of fuel.

Regarding the propriety of separating the refuse substantially into ashes, dry rubbish and kitchen garbage, much can be said on both sides. The wisdom of separating the ashes in Trenton from the rest of the refuse, under the present circumstances, should be considered only from the economical point of view. That is, would the amount of unburned coal remaining in the ashes after sifting make it unnecessary to purchase clean coal for assisting the fires in the furnace, and would the total expense of delivering the ashes at the crematory, of sifting them and subsequently disposing of the siftings, be less than that of the present method? I am not prepared now to answer this question, as it would require an investigation much larger than was necessary for present purposes, and was not undertaken also for the reason that the installation of the furnaces is not sufficiently large to treat the great bulk of clinkers, slag and ashes that would thus be added to the fires and also require temporary storage.

To compare the garbage of Trenton with the same class of refuse in London, Berlin, New York, and Boston, of which I have the information, Table I is presented, showing the various percentages of material of which garbage is generally composed. The table gives only a partial list of the materials which in some of these cities were quantitatively determined, and includes only the garbage proper for the purpose of comparing it with that of Trenton.

TABLE I.—PERCENTAGE COMPOSITION OF GARBAGE IN CERTAIN CITIES IN EUROPE AND THE UNITED STATES, EXCLUDING ASHES, COAL AND NON-COMBUSTIBLE RUBBISH.

	London.	Berlin.	New York*	Boston.	Trenton.
Authority	Codrington.	Bohm & Grohn.	Craven.	O'Shea.	Special Committee on Garbage.
Kitchen garbage, animal and vegetable matter	77	80	64	84	84
Paper	23	11	28	16	12
Rags, clothing, carpets, etc.		3			3
Boxes, barrels, and other rubbish		4	8		1

* Excluding Brooklyn.

The table shows that the garbage of Trenton is not very different from that of other cities, being as rich as any in combustible matter. The percentage of moisture, however, is very high, and though reliable data concerning this point are not available for all of the cities, I have reason to believe that it is higher than in any of the other cities given in the list. This of course is an important matter in any process of disposal by combustion.

Let us take, for instance, the thirty-one tons of garbage delivered in Trenton per day, with 81 per cent moisture. (See Table II.) This quantity will, therefore, contain approximately 24 tons of water which must be eliminated in the furnaces either by draining or evaporating before the garbage can be completely burned. Assuming that all must be evaporated in the furnaces and taking as a basis the usual value of ten pounds of water evaporated per pound of coal, it will require 2.4 tons of coal to evaporate this water. The twenty per cent solid material in the garbage, about ninety per cent of which is combustible, will daily yield roughly 6 tons of dry combustible material. With a conservative calorific value of one-

third that of coal, this gives an equivalent of 2 tons of coal, thus leaving a net average amount of about 0.4 ton of coal which must be added daily to consume the garbage with its present quantity of moisture. The amount of coal now actually consumed per day was found to be 2.3 tons. It is therefore clear that the

TABLE II.—RESULTS OF OPERATION OF GARBAGE CREMATORY AT TRESTON FOR WEEK OF AUGUST 4-9, INCLUSIVE, 1902.

Total garbage burned, tons	188.0
Garbage burned per ton of coal, tons	13.8
Coal used on main fires, tons	10.7
Coal used on auxiliary fires (estimated), tons	3.0
Total coal used, tons	13.7
Coal used per day, tons	2.3
Garbage burned per ton of coal, tons	13.8
Approximate number of hours burning each day, average	14.0
Equivalent number of days of 24 hours for the week	3.5
Equivalent garbage burned per sq. ft. of grate area per day of 24 hours, pounds	1,080
Equivalent amount of garbage burned per cell of 25 sq. ft., per day of 24 hours, tons	13.3
Estimated total amount of clinkers from garbage and coal grates, tons	14.0
Estimated total amount of ashes from below grates.	3.0
Estimated total amount of ashes and clinkers, tons.	17.0
Per cent of ashes and clinkers to garbage burned, tons	9.1
Range of temperature of flue gases in stack (estimated), deg. F.	600-1,000
Percentage of moisture in garbage	81.0
Corresponding water evaporated daily in furnaces, tons	25.5
Amount of coal required per day to evaporate this water on basis of 10 pounds water per pound coal, tons	2.5

arrangement of the furnace or the manner in which it is operated, or both, are not economical. At certain seasons when the garbage is not so moist as now, it seems that less or even no coal, except to start the fires, may be needed other than on rare occasions.

(To be continued.)

THE CODE OF KHAMMURABI.

"IN that day, I, Khammurabi, the glorious Prince, the worshiper of my God, justice for the land for witness, plaintiff, and defendant; to destroy the tyrant, and not to oppress the weak like unto the sun god, I promulgated." With these astonishing words open one of the most remarkable historical monuments that has ever been recovered from the buried cities of the ancient world. As we read this record of a king who must live for all time as the Father of Laws, it seems impossible to believe that we have in this carefully drawn series of laws a code a thousand years older than the Mosaic age, older than the laws of Manu or Minos, or any system of ancient legislation. Not only is this the fact, but there are ample indications that the laws which this great Oriental ruler so carefully codified are many of them of far greater antiquity than his reign, somewhere about B. C. 2200.

The monument and the circumstances of its discovery are alike remarkable. The monument itself is a pillar of black diorite, eight feet high, was found by M. de Morgan at Susa, in the Acropolis mound, on December and January, 1901-2, and the whole has been carefully photographed and published, with a translation by Father V. Schiel, O. P., the Assyriologist of the expedition, by order of the French Minister of Public Instruction, by Messrs. E. Leroux et Cie. The obverse of the column is surmounted by a plaque in bas-relief, which represents the king standing before the throne of a seated divinity, from whose shoulders flames of fire proceed to form wings, who is dictating to the king the laws. Dr. Schiel would identify this figure with the sun god; but it is more probably the old Bel or Ellu, the god Sadu-rabru of the "great Mountain" or El Shaddai, who figures prominently in the text as the god who inspired the king. In the opening of the inscription he is called "the Supreme God, the King of the Spirits of Earth, the Lord of Heaven and Earth who foretells the destiny of all." And the great prominence given to Nippur, the holy city of Bel, and his temple, "the Mountain House," would confirm this conjecture. The old Bel was the god who dwelt on the mountain of the world and gave laws to men, and wore on his breast the tablets of destiny. So here we have a curious proof of the existence of the tradition of the mountain-given law long before the Mosaic reception on Sinai.

INSCRIPTION ON THE MONUMENT.

The inscription which covers this stately monolith is the longest Babylonian record ever discovered. It contained originally about three thousand lines of writing, divided into forty-nine columns; but five columns on the front have been erased by some Elamite King, probably Sutruk Naknunti, who served the stele of Naram-Sin in a similar manner. The writing is a very beautiful type of the best archaic script, a kind of black-letter cuneiform, long used by kings for royal inscriptions, after the cursive writing was invented—as, for example, the Cyprus monolith of Sargon II., B. C. 721, in the Museum of Berlin. The inscription opens with a long enumeration of the king's titles, of his installation as king by the gods, and of the elevation of Babylon to the position of capital. This portion of the inscription, if not eclipsed by the code, which follows it, would be regarded as one of the most important historical records ever discovered, for it abounds in references to public works and historical events of the period. We must, however, notice one most important passage which throws great light upon the history of Assyria at a much earlier period than hitherto known. In one of the letters of this king recently published there is the reference to moving troops from Assyria, but the new find is more explicit. We read—the king is speaking of himself—"(I am) the settler of the tribes, the director of the people who restored its propitious genie [winged bull] to the city of Assur, who caused it to shine with splendor; the king who in the city of Nineveh, in the temple Dub-dub (?) has made brilliant the adornments of the goddess Istar." Hence not only Assur, but Nineveh also, contemporary with the time of Khammurabi. Is the passage in Gen. x. 11 based on this spread of Babylonian rule?

We now pass to the code, which occupied nineteen columns, and is divided into about 280 clauses, and which is introduced by the words, "Law and justice I established in the land, I made happy the human race in those days." How little King Khammurabi thought of the truth of his words uttered some 4,000 years ago, for from this code came the basis of the Mosaic code, and by that the races of mankind are largely ruled. One other important point remains to be noticed. What was the reason of the erection of this monolith and its inscription? The king tells us: "The law of the land as to judgments, the decisions of the land as to decisions, my precious decrees for the information of the oppressed upon this stone I wrote and placed in the temple of Merodach in Babylon." Were it not for the evidence of the king's letters in the British Museum, which show how he concerned himself with the humblest of his people, this would seem a vain boast. The remarkably simple wording of the text, the purest language—freedom from ideograms—show how it was evidently intended to be consulted by all who were "poor and afflicted." Surely such a monarch has a just title to use the remarkable words: "I was a master who was unto my people as the father who had begotten them."

CHARACTER OF THE CODE.

The code is a remarkable document; it shows a most careful and systematic order, beginning with witchcraft, which, perhaps, connects it with a religious code; it passes through all grades of social and domestic life, ending with a scale of official wages for all classes of workmen, even the lowest in the scale. In this notice it is impossible to deal with more than a small portion of the work, sufficient to show the general principles on which it is based. As the laws of witchcraft are rather outside of the general scope of the code, but preserve a most curious custom—namely, the "ordeal of water"—we may just notice them.

"If a man has placed an enchantment upon a man, and has not justified himself, he upon whom the enchantment is placed to the Holy River [Euphrates] shall go; into the Holy River he shall plunge. If the Holy River holds [drowns] him he who enchanted him shall take his house. If on the contrary, the man is safe and thus is innocent, the wizard loses his life and his house."

The same ordeal was applied to a wife for unfaithfulness or extravagance, or to a wineseller who sold drink too cheap.

The three essential features of the code may be clearly defined. First it is based on personal responsibility and the *jus talionis*, and tempered with the law of ransom; next the belief in the sanctity of the oath before God, as in the Hebrew code, and also the absolute necessity of written evidence in all legal matters, as became a nation of scribes. Judgments in the law courts required a "sealed" document; an agent must take and give receipts for all money or goods intrusted to him; bonded goods required a deposit note. One of the most interesting series of clauses relates to officers or constables employed on active service; the estate of such a person could be intrusted to management, must not be sold or mortgaged, but he must depute a representative, or three years' absence and neglect forfeited fief. Substituted service was not allowed. As might be expected in a land so rich in cultivation, the agricultural laws are most explicit. Land must be cultivated, and if neglected the owner had to pay the same as neighboring land. Damage to crop by storm excused the payment of interest on loan. There are very stringent laws as to the tending of the irrigation canals and ditches, and any damage to adjacent land by neglect had to be made good. The commercial laws are extremely important, as showing a highly developed system, such as we might expect from the trade activity of the Babylonians. Especially curious are the clauses relating to agents or peddlers, commercial travelers of the period. The name for the agent means one who carries "the stones (weights) in the bag," a phrase used for traders in Isaiah (xlvi., 6) and Proverbs (i., 14). To quote some passages:

"If on the road on his business, the enemy the property he bore have cause him to lose, the agent by the name of God shall swear and he shall be quit. If a merchant gives goods to an agent to trade with the agent shall write down the money, and to the merchant he shall render, the agent a sealed (receipt) for the money he gave to the merchant shall take."

LAWS GOVERNING MONETARY TRANSACTIONS.

Money for which no receipt was taken was not to be included in the accounts. In case of dispute all witnesses and documents must be produced. Among the commercial laws are some of much interest at the present time relating to licensed premises. It is curious to note that all wine merchants were females.

"If riotous persons assemble in the house of a wine merchant and those riotous persons she seizes not and drives to the palace that wine merchant shall be put to death."

Curious, too, is the following: "No votary or woman not residing in the cloister might open a wine shop or enter one for drink on pain of being burned." Have we here a Nazarite law?

Passing now to domestic legislation, the most striking feature is the high position and legal protection extended to women. If a man caused a votary or the wife of a man "to have the finger (of scorn) pointed at her and has not justified himself" he was to be branded on the forehead. To justify herself from scandal a woman could claim the ordeal of plunging in the sacred river. The mere formula of marriage "taking to wife" was not sufficient, for "if a man married a woman and executed not her deeds that woman is no wife." Divorce law is most fully given—a childless woman could be divorced. If divorced without cause the husband must allow alimony and custody of her children, and a portion of the estate equal to a son, and the woman was free to marry. The woman could get divorce, but must justify her right to do so. This is one of the most interesting clauses in the code. Thus we read:

"If the wife of a man who dwells in the house of that man has set her face to go forth, and has acted the fool, and wasted his house, and impoverished his house, they shall call her to account. If the husband shall say, I put her away, he shall put her away. She shall go her way; for her divorce he shall give her nothing."

If the husband insisted, such a wife could be drowned. There is, however, a kindlier tone in the law as to a sick wife. "If a man has married a wife, and sickness has seized her, he may take a second wife, but the sick wife he shall not put away; in the home she shall dwell; as long as she lives he shall sustain her."

THE LAWS OF PROPERTY.

Space will not permit of our dealing with the laws of property, which are most full and based on a most equitable system, but one clause certainly comes as a surprise, when we remember the antiquity of this code. It relates to the remarriage of a widow with young children, and might be present-day law:

"If a widow whose children are young has set her face to enter into the house of another, without the consent of the judge she shall not enter. When she enters into the house of another, the judge shall inquire regarding the house of her former husband. The house of her former husband to that woman and her future husband he shall entrust and cause them to deposit a deed. They shall keep the house and rear the little ones, but furniture for money they shall not sell. A purchaser that has bought any furniture from the children of the widow shall forfeit his money and return the property to its owner."

Here we have all the essential features of the modern ward in chancery. The temple in Babylonia was the heart of the city. It was there in the Surinam or judgment hall that cases were tried. The court of the temple was the modern Chancery Court, administering intestate or disputed estates. The treasury of the temple was bound to pay the ransom of a captive official.

We now come to the important question of the relation of this code to the Law of the Covenant and the Deuteronomy laws of the Hebrews. At once we find an astonishing agreement. Both are laws based on the *jus talionis*. The Hebrew is emphatic on this (Exodus xxi., 23-24). So the Babylonian Code (clauses 196-201). A curious parallel is afforded by one clause on unintentional assault. "If a man has struck another in a quarrel and caused him a wound, and that man shall swear 'I did not strike him knowingly,' he shall answer for the doctor" (compare Exodus xxi., 19, where the assailant is "to pay for loss of time and cause him to be thoroughly healed"). The Hebrews punished an assault on the father by death, the Babylonians by loss of the hands. The most striking example, and an almost undoubted proof of connection, is found in the clauses relating to goring by an ox. "If a man has a savage ox in his charge and it has gored a man and caused him to die, there is no claim." So also the Hebrew law (Exodus xxi., 28). But if the ox has pushed a man, and by pushing him has made known his vice, and he has not blunted his horn, has not shut up his ox, and the ox has gored a free man and caused him to die, he shall pay half a mana of silver (30 shekels). The Hebrew penalty was death, or a redemption at a fixed penalty, fixed by the judge. It is curious to find doctors coming under a penalty of *jus talionis*—an unsuccessful operation was drastically punished by cutting off the hands. We find also the barber surgeon practising chiefly for the branding of slaves.

Many other close similarities between the Babylonian Code and the Hebrew might be traced, but sufficient have been noticed to show that the Law of the Covenant at least must have been influenced by this code. It was during the time of the dynasty of Khammurabi and the subsequent Kassite line—that is, for some seven centuries—that Babylonian influence was predominant in Palestine and Syria, and, although the Rameside conquests and the Israelite invasion obliterated much of it, such a code would not die out, and, indeed, much of it exists to this day in the land laws of the Palestinian fellaheen.

One last remark. This code shows the wonderful organizing faculty of these ancient Arab rulers of Babylon, who laid the foundations on a basis which endured, we might say, to all time—for their work is with us unto this day, and the words which occur in the opening column are, after all, no vain boast—"Of Babylon they proclaimed its noble name and exalted it among the nations; within it he established an everlasting dynasty, which like heaven and earth is its throne." And no one did more to exalt the name of Babylon than this mighty king-lawgiver, the father of his people, who but a few years ago was unknown to us even by name.—The London Times.

AN IMPORTANT SCIENTIFIC EXPEDITION.

AN expedition has been fitted out by the California Academy of Sciences to visit the Revillagigedo Islands, and has just departed. The purpose of this important expedition is to make extensive investigations in the fields of ornithology, botany, conchology, biology, and anthropology, and it is expected that valuable specimens will be collected, and also many important scientific facts obtained.

Ornithologist R. H. Beck, chief field assistant of the Academy of Sciences, will be in charge of this expedition. A. S. Bunnell is the Assistant Ornithologist; C. H. Marks is Anthropologist, and E. E. Barkelew, Botanist. These gentlemen are also connected with the State University of California. Edward Gifford will have special charge of Conchology.

The schooner "Mary Sach," which has been employed on similar expeditions, has been chartered for the trip. Several months will be required to make the required investigations.

The Revillagigedos are a group of four uninhabited islands lying off the Mexican coast, about 240 miles southwest of Cape St. Lucas.

These islands are all of a rough, volcanic formation, and are the dwelling places of doves, hawks, elf-owls, warblers, mocking birds, wrens, frigate birds, and many as yet unclassified winged creatures, which are found nowhere else.

There are a great many strange plants, shrubs, etc., which have never yet been classified botanically.

While the greatest attention will be paid to the Revillagigedos by these scientific men, all uninhabited

islands passed on the way down will receive a thorough inspection.

Particular opportunities will be afforded Mr. Marks, the anthropologist; such as determining the linguistic stock of the Indians living in the vicinity of Todos Santos Bay, and having a good ground for a research for aboriginal remains in Natividad Island, which was probably once the stepping stone between Cerros Island and the mainland.

According to the accounts of the early Spanish navigators, it was once inhabited.

Three species of breeding stormy petrels (Mother Cary's chickens), of great variety, make their home on San Bernito Island off the coast of Lower California in Sebastian Vizcaino Bay. These scientists expect to return with a large number of valuable specimens.

This expedition will cover a period of five months or more, as ample time is desired to accomplish the different purposes in view.—J. M. B.

THE CROMPTON POTENTIOMETER FOR ELECTRICAL MEASUREMENTS WITH DIRECT CURRENT SUPPLY.*

SOME time ago Prof. J. A. Fleming, Fellow of the Royal Society of London, suggested the measurement of electric current direct from the supply by means of the instrument potentiometer, but its introduction into engineering practice has only recently been effected through Lieut.-Col. R. E. B. Crompton, of the Royal Engineers of Great Britain. The feature of this instrument is that it can be applied to running machinery and other apparatus which it is desired to test by means of leads, which at the precise moment that the observation is taken carry no current, and only serve to communicate the potential of the point to which they are attached. Already the Crompton potentiometer is in use, in many electric lighting and power stations in England, as the standard instrument for verifying apparatus of all kinds, and of measuring the output of the machines and the station.

Fundamentally, the instrument consists of a long wire carrying a current of electricity from a constant battery. If the wire is of uniform size and quality throughout, the potential difference between any two points is proportional to the length of wire intercepted between them. In Fig. 1 the current from a constant battery passes along the wire *a a* in the direction of the arrows. Some source of electromotive force, such as a battery cell *b*, is connected through a galvanometer to two sliding contacts, i. e., which are adjusted till the galvanometer deflection disappears. When this has been done the E. M. F. of the cell *b* is equal to the potential difference between *c c*. If *b* is now replaced by another cell *b'*, and the sliders adjusted to *c' c'*, so that the galvanometer deflection again disappears, then the electromotive forces of the cells *b b'* are in the ratio of the length *c c* to the length *c' c'*. In this way the relative values of any number of electromotive forces may be compared with one another, provided that none of them is greater than the fall of potential along *a a*. The instrument known as the potentiometer consists of this wire, with the terminals, sliding contacts, and switches necessary for its convenient manipulation.

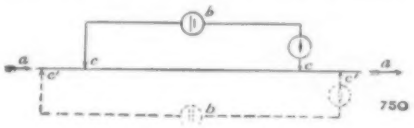


FIG. 1.

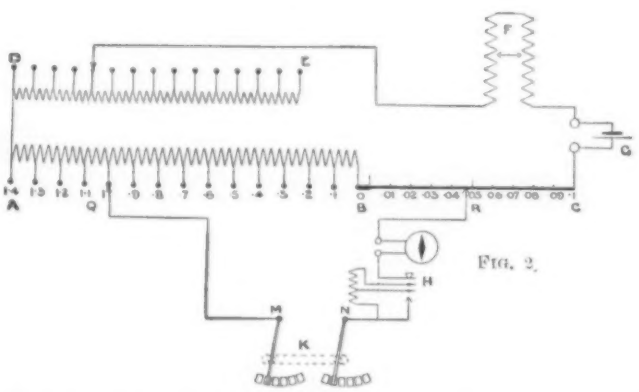


FIG. 2.

THE PRINCIPLE OF THE POTENTIOMETER'S CONSTRUCTION.

In the Crompton potentiometer the fall of potential along the measuring wire is adjusted to suit the case in hand by means of resistances placed in circuit with it, the maximum used in any case being two volts, derived from a single small accumulator.

The measurements most often required in direct-current work are those of potential difference and current. Potential differences are measured by comparison with the E. M. F. of a Clark cell.

Currents, on the other hand, are measured by passing them through a strip of resistance material, on which are fixed two terminals, the difference of potential between which, when any given current is passing, has previously been determined. All the resistances used for measuring current with the potentiometer consist of strips or spirals of manganin carrying stout terminals at the ends, to which the leads conveying the current are attached, and two smaller terminals connected to the potential points of the strips. The adjustment of the resistance strip consists in finding positions for the points, such that the potential difference between them has some convenient value for the currents they are designed to carry. A series of resistance strips are made to carry currents from 0.5 ampere up to 2,500 amperes or more, which give potential differences between their terminals convenient for direct comparison with the Clark cell. The value of the resistance assigned to one of these strips is not that between the main terminals, but that between the cross sections of the strip at the potential points. The current passing is the quotient of the measured potential difference between the potential points divided by the known resistance of the strip.

The principle of construction of the potentiometer may be clearly gathered from our second diagram. The calibrated wire is arranged in fourteen coils, called potentiometer coils, lettered *AB*, and a straight section *BG*, called the scale wire, the resistances of the several coils and of the straight section being equal. One sliding contact *Q* moves over the terminals of the fourteen coils, and another *R* along the straight wire. The reading of the instrument in the position shown is 1.046. The pairs of points whose potential differences are to be compared are connected to the blocks of the double-pole switch *K*, whose levers, *MN*, connect them, one pair at a time, to the sliding contacts *Q R* through the galvanometer. The galvanometer key *H* is arranged to complete the circuit through two resistances, which are short-circuited in succession as the key is depressed. The current required is derived from a small secondary battery *G*.

An adjustable resistance, consisting of a set of coils *DE* and a continuous rheostat *F*, is placed in the circuit. By adjusting these the resistance of the circuit and the current passing through it from the storage cell, and consequently the fall of potential along the scale wire, can be continuously altered, and the operator is able to obtain a galvanometer balance against a standard cell when the reading of the sliders is that of the known E. M. F. of the cell and its actual temperature. If, for example, the temperature of the cell be 15 deg., so that its E. M. F. is 1.434 volts, the sliders may be set to that reading and the galvanometer brought to zero by adjusting the resistance *DE* and the rheostat *F*. When this has been done, the scale readings at all points are direct readings in volts.

All the moving contacts are under glass, and the coils and the scale wire are inside the box. The box itself is completely closed, but the inside can be inspected by removing a sliding bottom. Nearly all the measurements made involve the use of a standard cell and one pair of terminals; the pair *A*, is assigned to its connections to save confusion in working. Fuses of fine wire are inserted at all terminals except those for the galvanometer, to save the instrument coils in the case of an accidental connection to a source of high pressure.

Two scales are engraved for slide-wire readings. One is a series of even divisions from 0 to 105, the resistance of the scale wire between 0 and 100 being the same as that of each potentiometer coil. It has been found convenient to be able to take readings at little beyond the 100 mark without having to move the potentiometer coil switch, and the scale is extended to 105 to admit of this. The other scale gives the values of the Clark cell at different temperatures, and is used in the following way: The potentiometer coil switch is set to 14, and the slide to the temperature of the Clark cell taken from the thermometer attached to it. The potentiometer reading is then the correct value in volts of the Clark cell at that temperature.

THE GALVANOMETER.

By adjustment of the rheostat the galvanometer is balanced, and when this has been done the current in the potentiometer wire is such that readings at all points give correct values in volts, and the instrument is a direct-reading voltmeter. Its maximum range is then 1.5 volts, reading in thousandths of a volt, and by inspection to ten-thousandths.

Volt boxes are made in several different sizes, depending upon the maximum voltage required to be measured.

We also give a photograph of the galvanometer employed for use with the potentiometer with a diagrammatic explanation of the moving part of the instrument in Fig. 3. A circular coil of wire hangs by a bifilar suspension between the poles of a permanent magnet, an iron core being fixed in the center. The suspension ligaments are of very thin copper strips, and are connected to the coils by means of a silver clip, which allows the coil to be easily disconnected. The mirror is hung from the coil by fine aluminium hooks passing through holes pierced in the mirror, so that it is easily detached, and is not distorted by the setting of cement or the pressure of a clip.

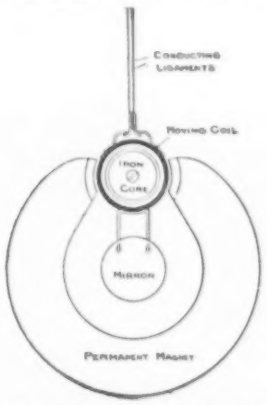
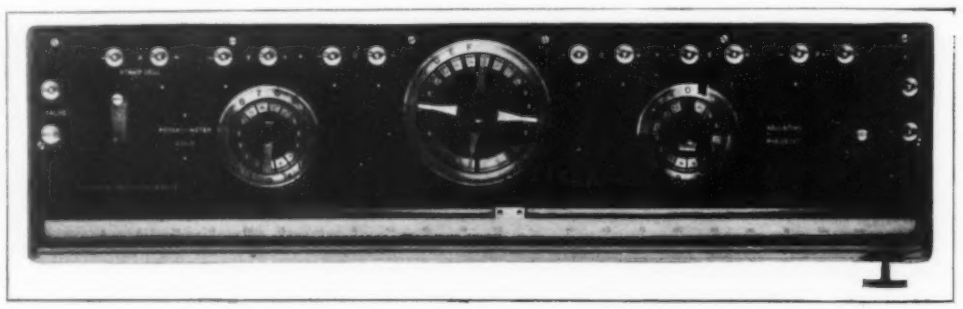


FIG. 3.—THE GALVANOMETER.



THE CROMPTON POTENTIOMETER.

Coils are made having different numbers of turns, from 100 upward, and the sensitiveness of the instrument when adjusted to give a complete period of oscillation of from 8 to 10 seconds is nearly as follows:

Number of turns in coil.	Resistance including ligaments.	Deflection of beam in minutes of arc.	
		For 1 micro-volt.	For 1 micro amp.
100	2 ohms.	0.6	35
300	30 ohms.	3.5	105
1,000	1,000 ohms.	0.6	350

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

These coils can be fitted, if desired, with small closed rings of copper, which damp their movements to any required degree. Without such damping rings the coils are for practical purposes perfectly ballistic. Where the sensitiveness of the instrument may be reduced, the connection of a short piece of high resistance wire across the terminals is conveniently used to damp the coil.

An electric lamp used without a lens is the most convenient light for these galvanometers, the filament being focused on the screen by the mirror. The mirrors are large, 25 mm. diameter, are accurately formed, are protected by mica, which produces no optical interference, and are hung in such a way as to suffer no distortion. They throw an image of the carbon filament on a semi-transparent screen, which is easily observed in broad daylight. The mirrors are ground to a radius of one meter. The lamp used has a filament with straight vertical limbs, and is mounted in a brass cylindrical case, with a straight slot, through which the light of one limb only falls on the mirror.

The scales are of transparent celluloid.

The Clark cells used as standards of reference of electromotive force consist of two cells mounted together in a brass case with a thermometer. If the values of the two cells measured on the potentiometer are the same, it may be assumed that both are in good condition; but if they differ, one of the pair at least is out of order, and should be examined.

LAND YACHTS MADE FROM OLD BICYCLES.

THIS is the time of year to build land yachts in order to take advantage of the spring breeze. Later, if you go to the seashore, you will find conditions for sailing along the beach ideal. Several clever boys who live on the upper west side of Manhattan have had lots of fun sailing small yachts along the wide city streets. Almost any broad, smooth thoroughfare will afford enough wind at this season for a small land yacht.

The pictures shown here are of the kind which have been built for racing on Florida beaches where there is a hard sandy surface hundreds of feet wide and many miles long.

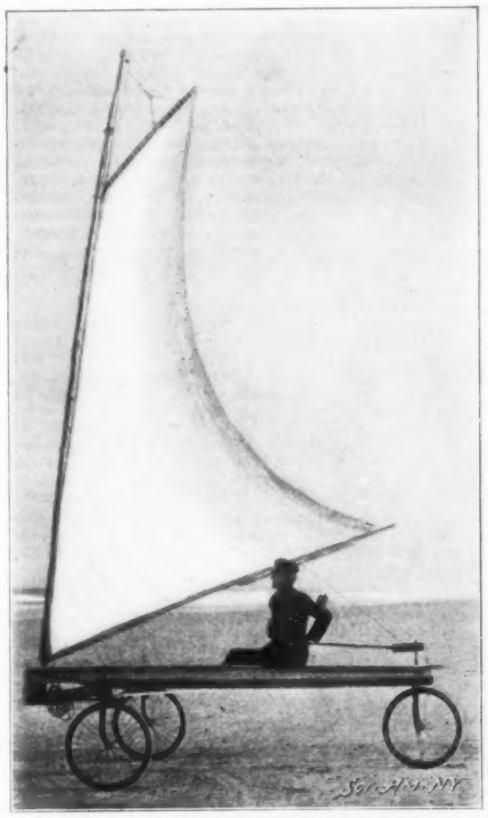
These yachts are made of heavy wood frames and the forward wheels of bicycles. The frames are very stiff and will carry an immense sail area, but in building a smaller yacht for sailing in the interior of the country the frames need not be so heavy. In the model shown here only two pieces of timber are used to support the mast. These timbers are braced with heavy wire. The builder should be careful to get new wire and it should be doubled. After the entire frame is wired the builder should take a long wire nail or some strong piece of metal about the size of an ordinary lead pencil, place it between the wire at different points around the frame and twist the wires until the frame is drawn together perfectly rigid.

The best wheels obtainable for any type of land yacht, large or small, are the front wheels used on bicycles. They have a strong fork, and the neck of the fork can be easily fitted through the backbone and cross beam of the yacht.

To hold the wires the builder should use heavy steel screw eyes. If the backbone and beam are made of pretty hard wood, screw eyes will hold heavy wire and will permit of its being twisted taut.

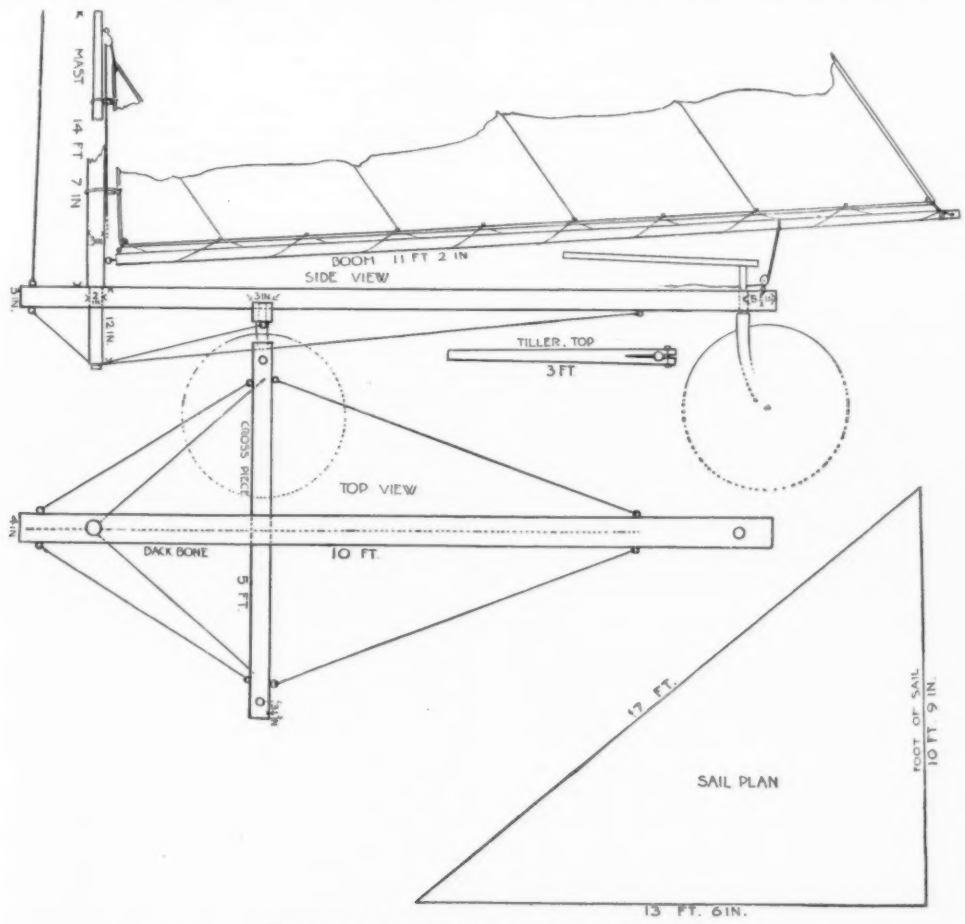
Care must be taken not to place the cross beam too far back of the bow. The beam should be mortised into the backbone a little. The wheels on the beam, one on each end, must be stationary, and should be driven into very tight sockets. If they are not tight, of course, it would be hard, if not impossible, to steer the yacht with a tiller on the stern wheel.

If it is desired, seats made from the bottoms and backs of chairs can be screwed on to the backbone, but the land yachts which have been built for racing in Florida have not been fitted with seats. The racers



TYPE OF LAND YACHT COMPLETE.

find it best to sit directly on the framework.—We are indebted to the New York Herald for the drawings and article.



WORKING DRAWINGS OF LAND YACHT.

CONTEMPORARY ELECTRICAL SCIENCE.*

PHOTO-ELECTRIC ACTION OF SALTS.—Photo-electric dispersion—i. e., the expulsion of negative electrons during illumination of a charged surface, depends not only upon the intensity of the light, but upon its wave-length and the nature of the surface illuminated. For ultra-violet light almost every substance is photo-electric, but as the wave-length of the incident light increases, the number of photo-electric substances narrows down to a few metals like zinc, magnesium, aluminium, sodium, potassium, rubidium, cæsium, and their amalgams, together with the phosphorescent sulphides of the alkaline earths and the colored haloids of the alkalies and alkaline earths, some of which, like blue fluorspar, occur in nature, while others may be colored by the action of sodium and potassium vapors or by cathode rays. Such colorations have been recently produced by means of Becquerel rays, and Elster and Geitel have examined salts so colored for their photo-electric dissipation. They found one preparation of potassium sulphate particularly suitable, since its intensely green color was not too rapidly bleached by sunlight. They found that the electric dissipation of a charge was increased 42 times by letting sunlight fall upon the preparation after it had been in the dark. It is therefore evident that Becquerel rays are effective in preparing negative electrons for liberation by ordinary light.—Elster and Geitel, Physikal. Zeitschr., November 1, 1902.

ELECTROTYPE REPRODUCTION OF PHONOGRAMS.—The usual reproduction of phonograms, by a sort of pantograph, wears out the original after a few hundreds of copies have been taken. L. Azoulay, the founder of the phonogram museums of the Vienna Academy, and of the Paris Anthropological Society, has devised two methods by which any number of duplicates may be made of a single original, which, however, is destroyed in the process. A mold is taken of the original cylinder by electro-deposition of red copper, and the mold, which must be 2 millimeters or 3 millimeters thick, is subsequently nickeled. This mold forms the basis of both the processes. In the first process the mold is mounted on a mandrel in the shape of a truncated cone, and wax is poured in and allowed to cool very gradually, the mandrel being withdrawn at an opportune moment. In the other process a hollow cylinder of wax, somewhat shorter and narrower than the interior of the mold, is placed inside the latter, and heated and pressed against it from within by means of a caoutchouc bag inflated to some eight atmospheres, or by hydraulic pressure. After cooling, the wax detaches itself in both cases from the copper mold, and the latter is ready for another reproduction. —**L. Azoulay,** Comptes Rendus, November 17, 1902.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ON ELECTRONS.*

By SIR OLIVER LODGE, F. R. S., Vice-President.

INTRODUCTION.

IN Maxwell's "Electricity" published in 1873, section 57, the following sentence occurs in connection with the discharge of electricity through gases, especially through rarefied gases:

"These and many other phenomena of electrical discharge are exceedingly important, and when they are better understood they will probably throw great light on the nature of electricity as well as on the nature of gases and of the medium pervading space."

This prediction has been amply justified by the progress of science, and no doubt still further possibilities of advance lie in the same direction. The study of conduction through liquids first, and the study of conduction through gases next, combined with a study of the processes involved in radiation, have resulted in an immense addition to our knowledge of late years, and have opened a new chapter, indeed a new volume, of Physics.

The net result has been to concentrate attention upon the phenomena of electric charge, and greatly to enhance the importance of a study of electrostatics. Not long ago Fitzgerald used chaffingly to speak of electrostatics as "one of the most beautiful and useless adaptations of nature;" and it was becoming the custom with teachers who felt that they must attend exclusively to the practically useful, and not waste their students' time on decoration and superfluities, almost to ignore, or at any rate to scamper through, the domain of electrostatics, and to begin the study of electricity with the phenomena of current, and especially of the connection between electricity and magnetism.

And certainly from the severely practical point of view, as well as from many other aspects, this part of electrical science remains the most important; but to him who would not only design dynamos and large-scale machinery, to him who in addition to the training and aptitude of the engineer possesses something of the interests, the instinct, and the insight, of a man of science, to such a one the nature and properties of an electric charge, at rest and in motion, constitute a fascinating study; for there lies the key to the inner meaning of all the occurrences with which his active life is so intimately concerned—there lies the proximate solution of problems which have excited the attention and taxed the ingenuity of philosophers and physicists and chemists since men began to escape from the struggle for bare existence—that most immediately practical of all occupations—and felt free to devote themselves, some to art, some to literature, some to the accumulation of superfluous wealth, and some to the gratuitous pursuit of speculation and pure theory.

PART I.

First I must lay a basis of pure theory: we must consider the properties of the ancient and long known phenomenon called an electrified body.

Two substances placed in contact and separated are in general united more or less permanently by lines of force, the region between them being in a state of tension along the lines and of pressure at right angles. These lines have direction: they begin at one body and end at another, they map out a field of electrostatic force, and their terminations on one or other of the bodies constitute what we call an electric charge. Electric charges are of two kinds, one corresponding to the beginning of the lines, the other to their ends. To one class of bodies, called insulators, the lines appear rigidly attached; whereas in another class they slip easily along, and are transferred from one such conducting body to another in contact with it, with great ease.

The tension in the lines tends to bring the ends

* Excerpt from a paper read before the Institution of Electrical Engineers and published in the Journal of Proceedings of the Institution.

together as near as possible, giving rise to what is observed as electrical attractions and repulsions.

In empty space it is probable that the only way of destroying such a field of force is to allow the two bodies to approach each other, and thus shorten up the lines to nothing; though even so it is not probable that the charges are destroyed, but only approach so close that they have no external effect at any moderate distance. When matter is present, however, it may be able to assist this collapse of the lines in various ways, giving rise to the various phenomena of conduction and of disruptive discharge.

If one of the two oppositely charged bodies is sent away to a considerable distance, while the other is isolated and regarded alone, the lines of this latter start out in all directions in nearly straight lines, giving rise to the simple notion of a single charged body—a thing which is no more really possible than is a single magnetic pole. The other ends of the lines must be somewhere, though they may be so far away as to be spoken of as, for all practical purposes, at infinity.

Now consider how far this field of force belongs to the body, and how far it belongs to space, that is to the ether surrounding the body. The body is the nucleus whence the lines radiate, but the lines themselves, the state of tension, and other properties which they represent and map out, do not belong to the body at all; at each point of space there is an electric potential, and this potential represents something occurring in the ether and in the ether alone.

A CHARGED SPHERE.

Picture in the mind's eye such a charged body, say a charged sphere, and let it change its position; how are we to regard the effect of the displacement on its field of force? Nothing in physics is more certain than this, that when a body moves, the ether in its neighborhood does not move. The ether, in fact, is stationary; it is susceptible to strain, but not to motion; it is the receptacle of potential, not of locomotive kinetic energy.

The effect of the motion of the body, then, is to relieve the strain of the ether at one place and to generate it at another; the state of strain travels *with* the body, but *through* the ether.

Regarding the matter from the point of view of the ether, we might say that the field of force is constantly being destroyed and regenerated as the body moves. Regarding it from the point of view of the moving body, we should say that it carries its field with it.

The question now arises—and it is far from being an easy question—what sort of occurrences go on in the ether when this decay and regeneration of an electrostatic field is occurring, or when a field of force is moving through it? Can it adapt itself instantly to the new conditions, or does it require time? This matter has been studied, closely and exhaustively, by Mr. Oliver Heaviside.

Fix the eye upon a point a mile distant from the body; does the information about the motion of the body reach that point instantaneously, so that all the lines of force move like absolutely rigid spokes, every part simultaneously; and if so, how is the communication carried on so that the distant parts of the medium can be thus instantaneously affected? Or does the disturbance only arrive at the distant point after the lapse of a small but appreciable time; in other words, has there to be an adjustment to the new conditions—an adjustment which reaches the nearest parts first and the further parts later; and if so, what additional phenomena can be observed during the unsettled period.

The answer is that during the motion of the charged body, and even after the cessation of its motion, until the disturbance has had time to die away and everything to settle down into static condition again, the phenomena of *magnetism* make their appearance; a new set of lines of force quite different from the electrostatic lines (although they, too, exhibit a tension along them and a pressure at right angles) come into temporary being. These do not originate at one place and terminate at another; they are always and necessarily closed curves or rings, and in the present simple case they are circles all centered upon the path of motion of the charged body. At any point of space there are now three directions to consider: (1) there is the original direction of the electrostatic field—the original electric line of force; (2) there is the direction of the motion—that is, a direction parallel to the movement of the charged sphere; and (3) there is the direction at right angles to these two; this last being the direction of the magnetic lines of force—the direction of the magnetic field.

I spoke of the magnetic field as temporary, but that is on the assumption that the charged body is merely displaced, moved from one position to another; if it is not stopped, but keeps on moving, then the magnetic lines continue as long as the motion lasts.

If we are asked whether such a magnetic field is weak or not, I have to reply that that depends entirely on how strong the charge is and how quickly it is moving. There is, in my opinion, no other kind of magnetic field possible; and so if ever we come across a magnetic field which we feel entitled to consider "strong," we must conclude that it is associated with the motion of a very considerable charge at a velocity we may properly style great. But certainly it is true that for any ordinary charged sphere moving at any ordinary pace—even supposing that it is a cannon-ball shot from the mouth of a gun—the concentric circular magnetic field surrounding its trajectory is decidedly feeble. Feeble or not, it is there, and to its existence we must trace all the magnetic phenomena of the electric current.

For just as there is no electrostatic field save that extending from one charged body to another, so there is no electric current except the motion of such a charged body, and no magnetic field except that which surrounds the path of this motion.

The locomotion of an electric charge is an electric current, and the magnetic phenomena surrounding that current are believed to be the only magnetic phenomena in existence. If any other variety is possible, the burden of proof rests on those who make the positive assertion.

One more statement:

While the charge is stationary everything is steady, and we have an electric field, only.

While the charge is moving at constant speed the current is steady, and we have a steady magnetic field superposed upon a steadily moving electric field, and a certain conveyance of energy in the direction of the motion.

But what about the intermediate stages, the stages of starting and stopping; what is the condition of things after the charge has begun to move but before it has attained a constant speed, and again when the brake is applied and the speed is decreasing, or when the direction of motion is changing? What phenomena are observable during the epoch of acceleration or retardation of speed or curvative of path? Something more than simple electrostatics and simple magnetism is then observed.

We get the phenomenon of induction—the generation of an induced E. M. F., of value at any point equal to the rate of change of the lines of magnetic force there. There being no conductor, this E. M. F. will propel no current, but it will represent an electric force which was not there before, and in a new direction, perpendicular to the direction in which the growing magnetic lines are moving, which is outward from the charge. Consequently the new or induced E. M. F. points in the direction of motion, though in the sense opposed to any change in it; and the effect of its superposition upon the magnetic field is to cause a certain small transmission of energy in a radial direction out and away from the accelerated charge. Some energy therefore flashes away with the speed of light, though in ordinary cases an exceedingly small amount.

It is from an electric charge during its epochs of acceleration or retardation that we get the phenomenon called radiation: it is this and this alone which excites ethereal waves, and gives us the different varieties of *light*.

Thus, or rather by means of a very extensive development of these fundamental ideas, are all the phenomena of electricity and optics summarized, and, so to speak, accounted for.

ELECTRIC INERTIA.

Whatever a charge may be, and whatever the hydrodynamic constitution of the ether, it must be able to maintain electric lines and magnetic lines, and to transmit energy wherever both sets of lines cross at right angles.

An accelerated charge is equivalent to a changing current.

Whenever a current changes we have an E. M. F. of self-induction set up.

Considered from the point of view of a current constituted by a moving charge, this corresponds to a mass acceleration.

And the electrical acceleration is opposed by the E. M. F., just as the acceleration of matter is opposed by its mechanical inertia. The co-efficient of the electric acceleration represents, therefore, an inertia term, and is properly called electric inertia.

By Lenz's law the effect of induction is always to oppose the cause which produced it. In the present case the cause is the acceleration or retardation of the moving charge, and so, in each case, this is opposed by the reaction of the magnetic lines generated by it.

Motion is opposed while it is increasing in speed, and it is assisted while it is decreasing in speed—an effect precisely analogous to ordinary mechanical inertia—and therefore force is necessary, and work must be done, either to start or to stop the motion of a charged body. An extra force, that is, by reason of its charge. Whatever the inertia the body may have, considered as a piece of matter, it has a trifle more by reason of its being charged.

Just as a changing magnetic field affects an electrostatic charge, that is to say generates a feeble field of electric force, into the intensity of which the velocity of light enters squared in the denominator, so it is with a changing electric field, it generates a magnetic field proportional to its velocity of change; and if it is being accelerated, the magnetic field itself varies, and in that case generates an E. M. F. which reacts upon the accelerated moving charge, and always in such a way as to oppose its motion—by what is called Lenz's law, or simply by the law of conservation of energy; for if it assisted the motion, the action and reaction would go on intensifying themselves until any amount of violence was reached.

The magnetic lines generated by a rising current, that is by a positively accelerated charged body, react back upon the motion which produced them in such a way as to oppose it. To oppose it actually or elastically, not passively or sluggishly, as by friction. The reaction ceases the instant the motion becomes steady: it is not analogous to friction, therefore, but to inertia; it is the coefficient of an acceleration term.

The magnetic lines generated by a falling current, that is by a negatively accelerated or retarded charged body, react oppositely and tend to continue the motion; thus here also we have a term corresponding to inertia. And the charged body may be said to have momentum by reason of its charge while it is moving. The value of the momentum is proportional to the velocity, so long as the velocity is not excessively great, and accordingly the inertia term is constant, and independent of speed, under the same restriction. It may therefore be considered to be in existence even when the charge is stationary, and thus it simulates exactly the familiar mechanical inertia of a lump of ordinary matter.

It is to be understood that whatever inertia a material sphere may possess, considered as matter, it will possess more when it is charged with electricity, and this no matter whether the charge be positive or negative. The amount of extra or electrical inertia is proportional to the electrostatic energy of the charge; that is to say, it is proportional to the charge and its potential conjointly.

Another way of putting it is to say that if a mass of a certain amount were moving with the speed of light, its kinetic energy would be half as great again as the potential energy of the electric charge when standing still.

Now any appreciable quantity of matter, even a milligramme, moving with the speed of light, has a prodigious amount of energy; namely, for the mass of one milligramme, fifteen million foot-tons. Or as Sir William Crookes has expressed it, a gramme, or fifteen grains, of matter, moving with the speed of light, would have energy enough to lift the British navy to the top of Ben Nevis.

Consequently the inertia of any ordinary quantity of electric charge must be exceedingly minute. Notwithstanding this, it is quite doubtful whether or not there really exists any other kind of inertia. The question whether there does or not is at present, strictly speaking, an open one; though to my mind it is practically closed.

The only way of conferring upon a given electric charge any appreciable mass, is to make its potential exceedingly high, that is, to concentrate it on a very small sphere.

A coulomb at the potential of a volt has an electrostatic energy of half a joule, that is $\frac{1}{2} \times 10^7$ ergs.

The mass equivalent to this would be

$$\frac{2}{3} \frac{10^7}{9 \times 10^{20}} = \frac{2}{27} \times 10^{-13} \text{ gramme} = 10^{-8} \text{ milligramme.}$$

Raise the potential to a million volts, and the mass equivalent to a coulomb at that potential would be the hundredth part of a milligramme; still barely appreciable therefore.

The charge on an atom as observed in electrolysis is known to be 10^{-10} electrostatic units. If this were distributed uniformly on a sphere the nominal size of an atom, viz., one 10^{-8} centimeter in radius, its potential would be one hundredth of an electrostatic unit, or about 3 volts. The energy of such a charge would be 10^{-12} erg, and the inertia of a body which would possess this energy if moving at the speed of light would be 10^{-33} gramme.

But this is incomparably smaller than the mass of a hydrogen atom, which is approximately 10^{-24} gramme. Consequently the ionic charge distributed uniformly over an atom would add no appreciable fraction to its apparent mass.

If, however, the atomic charge were concentrated into a sphere of dimension 10^{-13} centimeter, its potential would be 1,000 electrostatic units or 300,000 volts, its energy would be 10^{-7} erg, and its inertia 10^{-28} gramme, or about 1/1000 of the mass of a hydrogen atom.

All this is a preliminary statement of undeniable fact; that is to say of fact which follows from the received and established theory of electricity, whether such things as electrons had ever been found to exist or not.

All that we have stated is true of an ordinary charge on any ordinary sphere which can be made to move by mechanical force applied to it.

It gives us the phenomena
of electrostatics when at rest,
of magnetism when in motion,
of radiation when started and stopped,
and it incidentally, by reason of the known laws of electromagnetic induction, exhibits a kind of imitation inertia, and in that way stimulates the possession of the most fundamental property of matter.

I will add a few more closely connected assertions. Apply a sufficiently violent E. M. F. to a charged sphere, and the charge may be wrenched off it.

Insert an obstacle in the path of a violently moving charged sphere so as to stop it mechanically with *sufficient* suddenness, and again it is possible for the charge, or something like it, to be jerked off it and passed on. But to do this the speed of the sphere, as well as the suddenness of stoppage, must be excessive. Usually the charge is merely thrown into an oscillation, when the sphere is suddenly stopped; and it then emits a solitary wave or spherical shell of thickness equal to the diameter of the sphere; or greater than that diameter by the amount the sphere has moved during its retardation. When the acceleration is moderate, however, the radiation is less energetic and also less intense; less energetic because its power depends on the square of the acceleration, less intense because it is spread over a thicker ethereal shell. Röntgen rays are perceptible only when the speed was great and the stoppage so sudden that the wave or pulse shell is strong and thin.

(To be continued.)

WIND-BAGS AS BIRD LOVE CHARMS.

THE development among animals, and especially among birds, of purely ornamental wind-bags, used as adjuncts in courtship, forms the theme of an article in Knowledge for January by Mr. W. P. Pycraft, who writes: "These wind-bags, which, almost without exception, may be inflated and deflated at the will of the animal, differ much in the nature of their origin. . . . Take the common pigeon for example. Could anything appear more silly than the strutting, bowing and cooing of the cock aided by this very practice of filling his gullet with intoxicating draughts of the morning air, the which swells his neck to unduly large proportions, and apparently, on this account, makes him so much the more fascinating? With the pigeon tribe, no special receptacle is provided for the indrawn air. . . . The present greatness of the crop, we would point out, is due not so much to the efforts of the prancing bird as to the care and selection of the breeder. . . . A still more remarkable gullet pouch is that of the frigate-bird of the tropics. Bare externally, of a vivid scarlet color, and capable of being inflated till it is nearly as large as the rest of the body, this pouch is an invaluable asset to its possessor when seeking a mate. For here, as elsewhere, the successful suitor is he who makes the most of his peculiar charms; the prize falling to him who is able to display the biggest and most brilliantly colored pouch. Only the males wear this ornament, which is retained only during the breeding season. At this time a lively competition appears to take place, a dozen or so of these birds crowding together in a tree and greeting the approach of their prospective mates with inflated pouches and drooping wings, accompanied by a peculiar apology for a song, described as a sort of 'wow-wow-wow-wow,' and a noise resembling the sound of castanets, which is made by a violent chattering of the horny beak. The pouch of the frigate-bird is formed by the upper end of the gullet, and appears to be closed behind by a peculiar arrangement of muscular fibers to form what is known as a sphincter

muscle. These muscles close up the tube of the windpipe much as the mouth of a bag is closed by means of a double string."

SELECTED FORMULA.

Making Handkerchief Perfumes.—Any one familiar with the ordinary operations of pharmacy can easily learn to compound perfumes. The operations are simple; the chief thing to be learned perhaps is to judge of the quality of materials. As you state that you wish to make perfumes to sell to children in small bottles at a low price we will give you some formulas for second grade goods.

The term "extract," when used in these formulas means an alcoholic solution of the odorous principles of certain flowers obtained by enfleurage; that is, the flowers are placed in contact with prepared grease which absorbs the odorous matter, and this grease is in turn macerated with alcohol which dissolves out the odor. A small portion of the grease is taken up also at ordinary temperatures; this is removed by filtering the "extract" while "chilled" by a freezing mixture.

The extracts can be either purchased or made direct from the pomade (as the grease is called); to employ the latter method successfully some experience may be necessary.

The term "second" means a weaker extract than is used for first-class perfumes; it is obtained by "washing" the pomade a second time. A like result as to cost may of course be arrived at by diluting the better extract with alcohol.

The tinctures are made with 95 per cent deodorized alcohol, enough menstruum being added through the marc when filtering to bring the finished preparation to the measure of the menstruum originally taken.

The glycerin is intended to act as a "fixing" agent—that is to lessen the volatility of the perfumes.

Frangipanni.

Oil of rose	2 drachms
Oil of neroli	2 drachms
Oil of sandalwood	2 drachms
Oil of geranium (French)	2 drachms
Tincture of vetivert (1¼ to 8)	96 ounces
Tincture of tonka (1 to 8)	16 ounces
Tincture of orris (1 to 4)	64 ounces
Glycerin	6 ounces
Alcohol	64 ounces

Extract of Heliotrope.

Tincture of vanilla	64 ounces
Extract of rose (2d)	48 ounces
Extract of orange flower	2 ounces
Tincture of orris	4 ounces
Oil of rose	10 drops
Oil of bitter almond	6 drops
Tincture of bezoin (1 to 8)	2 ounces
Glycerin	4 ounces

Extract of Japan Rose.

Extract of rose (2d)	64 ounces
Tincture of orris	80 ounces
Oil of rose	½ ounce
Oil of rose geranium	½ ounce
Oil of sandalwood	2 drachms
Oil of neroli	1 drachm
Glycerin	5 ounces
Alcohol	64 ounces

Bouquet.

Extract of rose (2d)	64 ounces
Extract of jasmine (2d)	12 ounces
Extract of cassie (2d)	8 ounces
Tincture of orris (1 to 4)	64 ounces
Oil of bergamot	½ ounce
Oil of cloves	1 drachm
Oil of ylang-ylang	½ drachm
Tincture of benzoin (1 to 8)	2 ounces
Glycerin	4 ounces

Extract of New-Mown Hay.

Oil of rose	3 drachms
Oil of neroli	2 drachms
Oil of sandalwood	2 drachms
Oil of geranium (French)	2 drachms
Tincture of tonka	32 ounces
Tincture of vanilla (1 to 4)	32 ounces
Tincture of orris	64 ounces
Glycerin	8 ounces
Alcohol	64 ounces

Extract of Patchouly.

Tincture of orris	48 ounces
Extract of rose (2d)	32 ounces
Oil of patchouly	1 ounce
Glycerin	2 ounces
Alcohol	96 ounces

Extract of Rose Geranium.

Tincture of orris	32 ounces
Oil of rose geranium	1½ ounces
Glycerin	4 ounces
Alcohol	64 ounces

Extract of White Rose.

Extract of rose	96 ounces
Extract of jasmine (2d)	8 ounces
Extract of cassie (2d)	16 ounces
Tincture of orris	96 ounces
Oil of rose	2 drachms
Oil of patchouly	6 drops
Glycerin	4 ounces

Extract of Ylang-ylang.

Extract of cassie (2d)	96 ounces
Extract of jasmine (2d)	24 ounces
Extract of rose	24 ounces
Tincture of orris	4 ounces
Oil of ylang-ylang	6 drachms
Glycerin	6 ounces

Extract of Verbena.

Oil of lemon grass	3 drachms
Oil of lemon	½ ounce
Alcohol	16 ounces

If formulas for better perfumes are desired or any difficulties present themselves in the work, we will be glad to offer further instructions.—The Druggists Circular and Chemical Gazette.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Request for Agricultural Machinery in Russia.—Vice-Consul Hernando de Soto, of Warsaw, writes, March 27, 1903, that he has received a request for quotations on locomobiles—not too light—of 6, 8, 10, and 12 horse power, with one or two cylinders, combined with thrashing machines; special thrashing machine for clover; harvesting machines of all kinds; farming implements and combined extirpators. Full particulars are desired in regard to net and gross weight and the kind of fuel used. Prices should be quoted f. o. b. New York or delivered at Stettin or Danzig, Germany.

Metallic Tubing and Tube Furniture in Germany.—In reply to the inquiry of an Illinois firm (to which advance copy has been sent), Consul-General F. H. Mason writes from Berlin:

The manufacture of tubes and pipes from iron, steel, copper, and other metals and alloys, although of comparatively recent date, is one of the most extensive and highly developed industries of its class in Germany. There were in operation at the close of 1900 seventy-seven manufactories of metallic tubing, some of which—as, for example, Predboeuf et Cie., the Mannesröhrenwerke, and the Röhrenindustrie, all at Düsseldorf—are large establishments with ample resources and equipped with every facility for cheap production on a large scale.

The Mannesmann process for rolling seamless tubes and the Ehrhardt system by which seamless pipes are drawn by forcing a mandrel under hydraulic pressure through a block of metal are both German inventions which have been developed and worked with notable success in this country, while Larson's Swedish process for making steel tubes, the Murphy process, and the Robertson and Elmore patents for making copper and brass tubes are all employed here under the most advantageous circumstances.

The import duty on wrought iron and steel tubing is 5 marks ($1.19) per 100 kilogrammes (220 pounds) under the tariff law of January, 1896, now in force, and this rate is advanced in the tariff of December 25, 1902, to 8 marks ($1.90) for rough and 15 marks ($3.57) per 100 kilogrammes for polished or otherwise finished tubing. If the wall of the finished tube is less than 2 millimeters in thickness, the rate under the new tariff will be advanced to 20 marks ($4.76) per 100 kilogrammes.

Germany has both an import and an export trade in metallic tubing. The imports in that class during the eleven months ended November 30, 1902, amounted to 9,916 tons, of which 6,396 tons, or about two-thirds of the whole amount, came from the United States, the remaining third being derived from Sweden, Austria, Great Britain, and Belgium. To what special grade, size, or category these imported tubes belonged, or why they should have been imported in face of the vast home production and large export of German-made tubing can only be conjectured; there is nothing in the official statistics to explain it. But during the same eleven months of 1902, Germany exported iron and steel tubing to the amount of 50,505 tons—more than five times the imports in the same class—which were distributed to nearly every country of Europe and South America, the principal purchasers being:

	Tons.
Switzerland	8,382
Holland	7,382
Belgium	6,144
Russia	2,007
Mexico	1,618
Brazil	1,013

Among the various uses to which iron, steel, and brass tubing are applied in Germany, one of the most modern and important is the manufacture of furniture—especially bedsteads, cot frames, and tables for household, hospital, and military purposes. German science has long been in the front line of discovery and progress in all that relates to sanitary practice, the war against the myriad bacilli of human disease. Tubular metallic bedsteads are not only cheaper, lighter, and more easily flexible than those made of wood, but they offer no harbor for vermin and lend themselves readily and without injury to disinfection and all the processes of sanitation. For these reasons and because they are cheap, light, and serviceable, the manufacture of tubular bedsteads and other articles of furniture, which began in England and was adopted in Germany hardly a dozen years ago, now employs capital estimated at 15,000,000 marks ($3,570,000) and from 50,000 to 60,000 operatives. As the industry has developed, there has been a steady progress in the effectiveness of the machinery employed for shaping, cutting, and jointing the parts; soldered joints have given place to screw connections, detachable when desired.

Bedsteads are made either wholly of iron and steel tubing, of the same tipped and decorated with brass and nickeled mountings, or wholly of brass tubing, the latter class being, of course, the most decorative and expensive and adapted to luxurious households, hotels, and private sanitaria. When intended for hospitals, iron bedsteads are covered with a waterproof varnish, which protects them from oxidation or injury in cleaning or disinfection.

The manufacture of metallic-tube furniture is distributed over most of Westphalia and the Upper Rhine provinces of Germany, and there are two large and prosperous establishments in Berlin. Each of these manufactories turns out bedsteads, cots, military stretchers, etc., besides washstands, toilets, children's cots, etc., in hundreds of different models and forms, adapted to every location and purse. So cheap are the materials and processes of manufacture that the catalogue prices for the different classes of bedsteads range as follows:

Single iron bedstead:	
With plain iron fittings	$1.19 to $3.50
With spiral-spring mattress	2.38 to 6.00
Iron bedsteads with bronze ornaments and steel-spring mattress	6.00 to 24.00
Brass bedsteads with steel-wire mattress	24.00 to 95.00

It would hardly seem probable that an industry so widely and fully developed, protected by the costs of transportation and even by a moderate tariff, would leave an import market in Germany for any except the higher and more costly grade of brass furniture, which the English exporters were first to discover and utilize, but which has since been almost wholly recovered by the native German manufacturers.

Currant Crisis in Greece.—The economic structure of this kingdom rests largely upon the currant industry, and any question which agitates this becomes a national matter. The crisis has been impending since 1902, when prices opened, as a result of the enormous crop, 50 per cent lower than in the previous year. Popular sentiment is strong in favor of a bill the two main features of which are (1) the imposing of a tax on all vineyards hereafter planted and (2) the removal of the limit of the retention law, which at present permits the retention of as much as 20 per cent of the annual crop, in order to fortify prices. The former can have no external interest beyond the possibility of rendering the crop uniform in future years, since most of the available land is already under cultivation. The latter, however, takes on some complications from the attitude which is likely to be assumed by Great Britain.

When, in 1890, Great Britain reduced the duty on Greek currants from 7s. to 2s. ($1.70 to 48.6 cents) per cwt., it was with the understanding that no land tax was to be imposed by Greece upon currant-bearing districts. In the years that followed, the demand for the Greek currant was unparalleled, and the production increased until in 1899 the surplus was so large as to call for immediate measures. The Greek Currant Bank was organized and a bill voted which authorized the retention of as much as one-fifth of the annual crop of currants for the encouragement of home industries (especially of wine and spirit), the actual amount to be fixed by the prefects of the currant districts. England considered this law as a roundabout violation of the agreement between the two countries, but is said to have made no protest. The present agitation for the removal of this 20 per cent limit (that is to say, the fixing of no limit whatever to the amount of currants which may be retained, but allowing the matter to be governed entirely by the size of the crop) has caused the British minister at Athens to intimate that Great Britain will protest against any such law and may impose a prohibitive duty on this product. It remains for the Boulé at Athens to choose between the favor of England, whose markets buy heavily of the currant grape, and the strong sentiment of all currant-growing eparchies, which demand the immediate passing of such a measure.

English capitalists have proposed to the Greek government to form a monopoly of the currant trade (under the name of the Mercantile Bank of Greece, Limited) and to purchase the annual yield at a price between 200 and 400 drachmas ($25 and $50) per 1,000 pounds, in proportion to the quantity of the vintage. Not all the conditions of the proposed syndicate are known—in fact, it is not safe to assume that any of the published conditions are accurate—but the following has been made public:

The syndicate proposes (1) to spend £100,000 ($486,650) yearly for the preparation, cleaning, and packing of the currants; (2) to set aside £25,000 ($121,663) yearly as a reserve fund to secure the stability of exchange; (3) to contribute £80,000 ($389,320) yearly either directly to the Greek government or in the form of a subsidy for the Greek merchant marine; and (4) to spend £65,000 ($316,323) yearly in advertising the Greek fruit throughout the world, besides appropriating one-half the net profits to other interests in some way bearing upon the currant industry and consumption.

The proposition seems hardly feasible. The weakest point in the proposed monopoly is its failure to guarantee to use more than 130,000 tons the first year—it being understood that should a quantity of this first purchase remain unsold, the same would be carried over to the following year and the amount deducted from the second purchase. The strongest argument for the change in the retention law is that the retention of any amount of currants for home consumption can not be construed as equivalent to placing a tax upon the land which produces them, and therefore has no essential bearing upon the agreement existing between Great Britain and Greece. Upon this point the action of the British minister at Athens will be watched with interest.—Frank W. Jackson, Consul at Patras.

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No. 1632. April 28.—American Investments in Canada—German Fire Extinguisher.

No. 1633. April 29.—Government Monopolies in Formosa—Wheat Crop of India in 1902-3—Trade of Cartagena, Colombia—* Request for Agricultural Machinery in Russia—Hungary's Preparation for Specie Payments.

No. 1634. April 30.—* Metallic Tubing and Tube Furniture in Germany—* Currant Crisis in Greece.

No. 1635. May 1.—The Corinthian Canal.

No. 1636. May 2.—The Trans-Andine Railway.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECIPES.

Paint Coatings for Iron in Damp Rooms.—For dyeing, bleaching, and finishing establishments, etc., where the iron continually is exposed to steam, the said metal requires expert treatment by way of a carefully applied anti-rust coating, even in the case of new constructions. Of late, a number of anti-rust paints are appearing on the market, which generally fulfill their purpose if correctly used. It is a well-known fact that the best of anti-rust paints may yield unsatisfactory results, if it is not applied to the iron as directed. Above all, only iron free from rust should be painted. The manner of removing the rust coat depends upon the local conditions, upon the shape of the respective article, and the extent of the rust covering.

The removal of the rust may be accomplished mechanically by brushing, also by rubbing with pumice stone, as well as by pickling. The last-named process should be resorted to only in cases where another way of cleaning the object is impracticable. Another condition is to only paint iron that is entirely dry, a circumstance that should be borne in mind for all the subsequent coatings as well.

As a priming coat on iron one of hot linseed oil is best adapted, which should be applied evenly throughout so that all places are covered. This coat is followed—in case of new constructions before the putting together of the parts—by an application of pure red lead in linseed oil varnish. This is succeeded at intervals of six to eight days by two to three coats of paint, care being exercised that each coating is thoroughly dry before the next one is applied. The paint, which should be finely ground, must be rubbed out well with the brush, so as to avoid the formation of blisters.

It frequently occurs that whole iron constructions are painted by laborers without the work being supervised by experts. When after a while rust forms in places, the anti-rust paint otherwise known as reliable is blamed for the failure. It is best to have such work done only by skilled painters, and not by inexperienced persons. After the priming, all cracks, holes, and defects in the iron should be stopped up with a putty of red lead in linseed oil varnish and painted again after hardening. The paint should spread well, have good covering power, and should not contain benzine or any other hydrocarbides. The use of liquid siccatives as driers must not be resorted to. As regards the paint itself, any one can prepare it from red lead and good linseed oil varnish, and such a mixture, if the above hints are observed, will furnish a good, durable protection for iron in the open air or exposed to dampness.

A suitable coating for iron successfully resisting humid aqueous vapors is obtained by the following mixture: Boil or heat in a copper vessel 10 parts of unbleached shellac and 3 parts of borax in 100 parts of water, until all has turned into a uniform liquid. Then cover up the kettle and fill the cooled liquid in bottles, which must be closed up well. When the painting is to be done, the iron parts above all must be well cleaned and dry. Now add equal parts thick, unground oil paint and stir the substances intimately until a uniform liquid of painting consistency results. Of this mixture intimately mingle 2 parts with 1 part of the above-named shellac mixture. It is advisable, however, to combine the oil paint with the shellac mixture only a little before each application is to be made. It is also necessary to keep the mixtures in hermetically sealed bottles, pots or jugs, or else a little clean water is poured upon the oil paint to keep it from drying. Graphite paint is likewise said to be an excellent protective for the said purposes. It consists of a mixture of graphite in linseed oil. The graphite is powdered and ground with well-boiled linseed oil; 0.5 kilo of this mixture is diluted with 1 liter of linseed oil. A little siccative is added. Graphite is attacked neither by heat nor by cold, and offers resistance to the action of acids.—Werkmeister Zeitung.

Waterproof Varnish for Paper, Cardboard, and Cloth, Which May Serve Also as a Paint.—1. Ten grammes of octo-nitrocellulose are dissolved in a mixture of 50 cubic centimeters of amyl acetate and 50 cubic centimeters of 95 deg. alcohol. The liquid thus obtained is filtered through sheets of carded cotton.

2. Forty cubic centimeters of castor or palm oil, or any other vegetable oil, are mixed with such a color as ocher, chrome, or aniline, in sufficient quantity, according to the tint desired.

3. Liquids 1 and 2 are mixed together and worked up for four hours.

4. The paper, preferably not calendered, is placed in a roll behind a coating machine, similar to the one employed in the manufacture of oil cloth.

After having been kept for two hours in a drier, the paper is wound on a roller and passed either to the calendering machine in order to obtain the varnished surface, or to a figuring machine, which impresses the desired design. For obtaining a paint with this varnish, to 50 cubic centimeters of No. 1, 50 cubic centimeters of a mixture of Nos. 1 and 2 are added; one part amyl acetate and one part 95 deg. alcohol.

This paint holds very well on glass, iron, wood, plaster, and cement, and is of remarkable brilliancy.—From the French, in La Revue des Produits Chimiques; patent of M. Senechal de la Grange.

To Blacken Aluminium.—Here is a formula which might be tried:

White arsenic	1 ounce
Sulphate of iron	1 ounce
Hydrochloric acid	12 ounces
Water	12 ounces

When the arsenic and iron are dissolved by the acid, add the water. The aluminium to be blackened should be well cleaned with fine emery powder and washed before immersing in the blackening solution. When the deposit of black is deep enough dry off with fine sawdust and lacquer.—Inland Printer.

Black Brushing Color.—

Quillaya bark	1¼ kilos
Potassium bichromate	½ kilo
Logwood extract	3 kilos
Copper sulphate	¼ kilo
Water	60 liters

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